

The logo is a large, light blue triangle with a white border. Inside the triangle, there is a central illustration of a three-masted sailing ship (the Europa Clipper) sailing on a globe. Above the ship, a satellite is shown in orbit. The text 'EUROPA CLIPPER' is written in a stylized font across the middle of the triangle. Along the left edge, it says 'MPC * ASU * UTIG'. Along the right edge, it says 'SWRI * CU-LASER'. Along the bottom edge, it says 'JPL * NASA * APL'.

Europa Clipper Update to OPAG

Bob Pappalardo, Europa Clipper Project Scientist

Barry Goldstein, Europa Clipper Project Manager

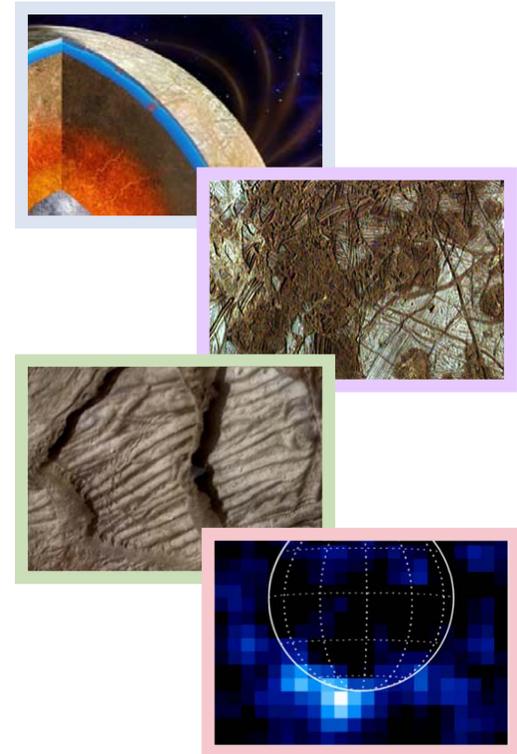
Jet Propulsion Laboratory, California Institute of Technology

September 11, 2018



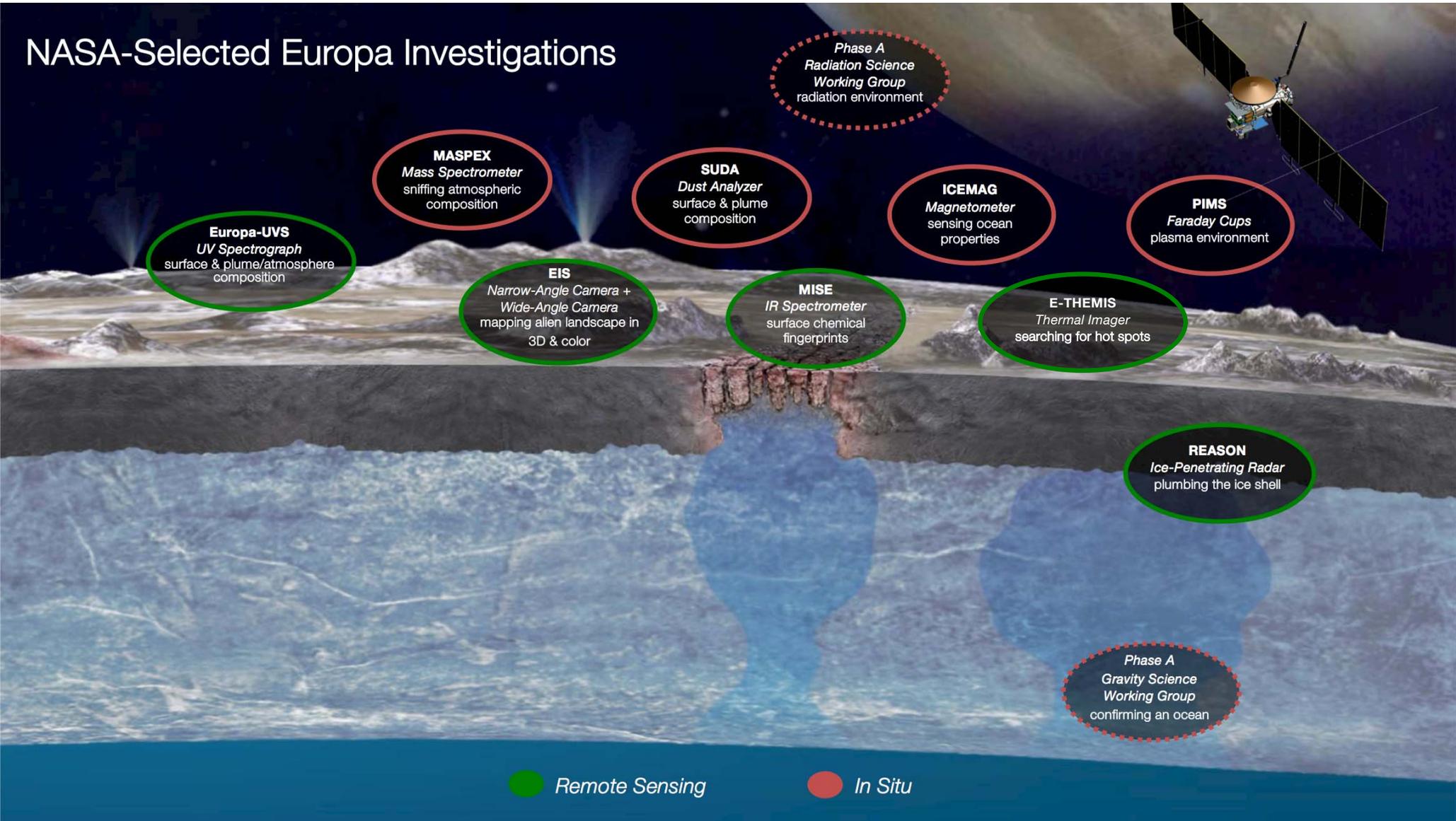
Europa Clipper Science Overview

- **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 Investigations





Europa Clipper Project-Level Lifecycle Schedule

Key Project Reviews

3/23/18

FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	
<div style="display: flex; justify-content: space-between;"> 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 </div>											
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PRE-PHASE A			PHASE A (20 mo)		PHASE B (20 mo)			PHASE C (26 mo)		PHASE D (18 mo)	PHASE E
NASA Reviews Project Reviews ▲ PCR ▲ MCR ▲ KDP-A 2/17 ▲ KDP-B 10/18 ▲ KDP-C 12/20 ▲ KDP-D 5/22 ▲ KDP-E 1/17 ▲ SRR/MDR 8/18 ▼ Project PDR 11/19 ▼ Project CDR ▲ SIR 10/20 PSR 1/22 ▲ ▲ MRR 4/22 3/22 ★ Launch 6/22											
06 Spacecraft REASON FS PDR PDR FS CDR CDR L3 FS Req (BL Rev C) 10/17 ▼ 11/17 11/19 ▼ 12/19 L3 FS Req (Baseline) ◆ L3 FS Req (BL Rev D) ▲ I&T Readiness Review											

We are here

PDR Season

Spacecraft

Payload

Mission System

Project

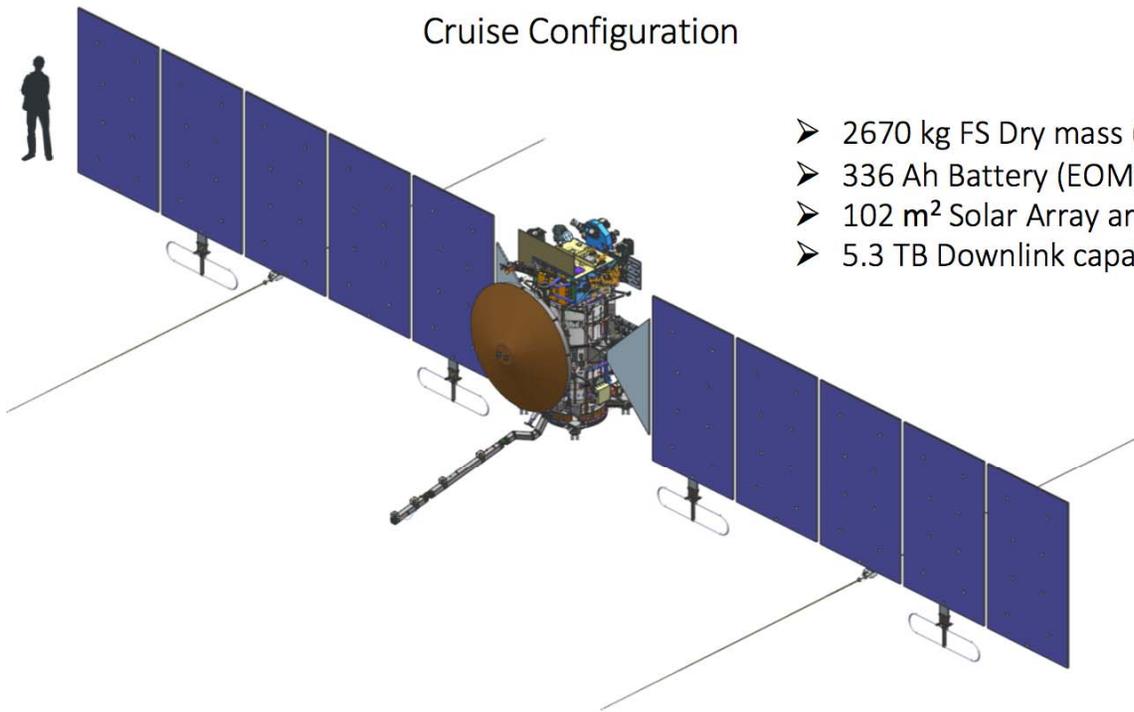
- Propulsion Subsystem PDR 6/27-29/17 (GSFC)
- Propulsion Module PDR 7/24-27/17 (APL)
- Flight System PDR 10/17-20/17 (JPL)
- Europa-UVS PDR 11/16-17/17 (SWRI)
- PIMS PDR 12/6-7/17 (APL)
- EIS PDR 1/9-11/18 (APL)
- Solar Array Requirements Review 1/22/18 (JPL)
- Power PDR 1/23-24/18 (JPL)
- SUDA PDR 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)

- 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)

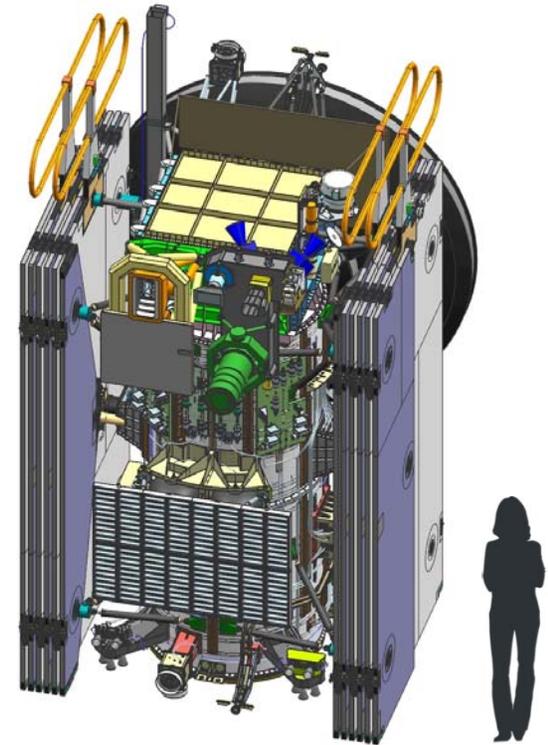


Flight System Configuration

Cruise Configuration



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

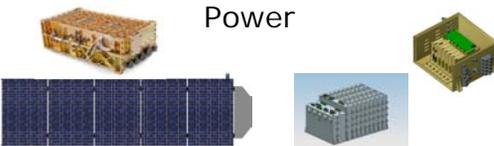
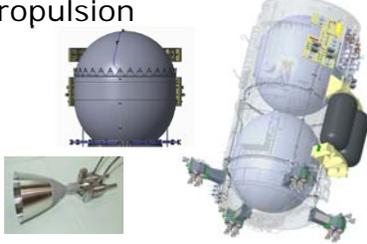
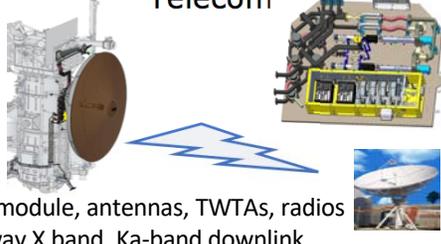
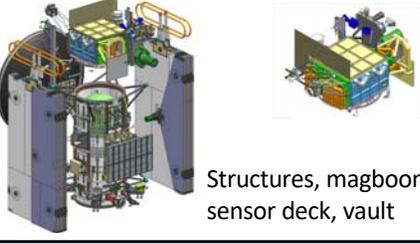


Launch Configuration

Flight System = Spacecraft + Payload

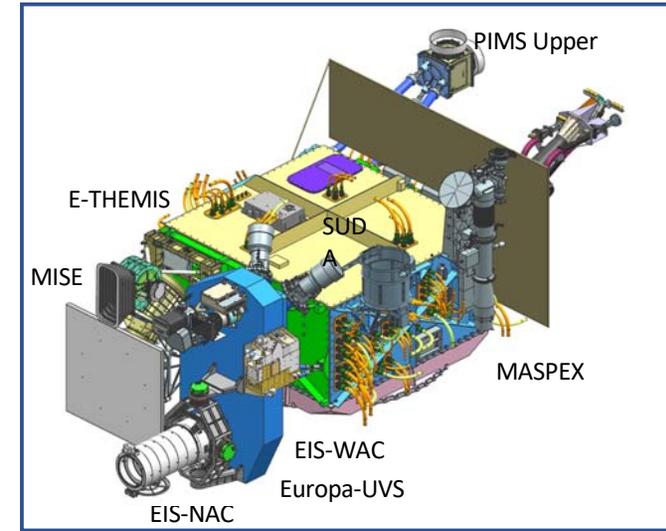
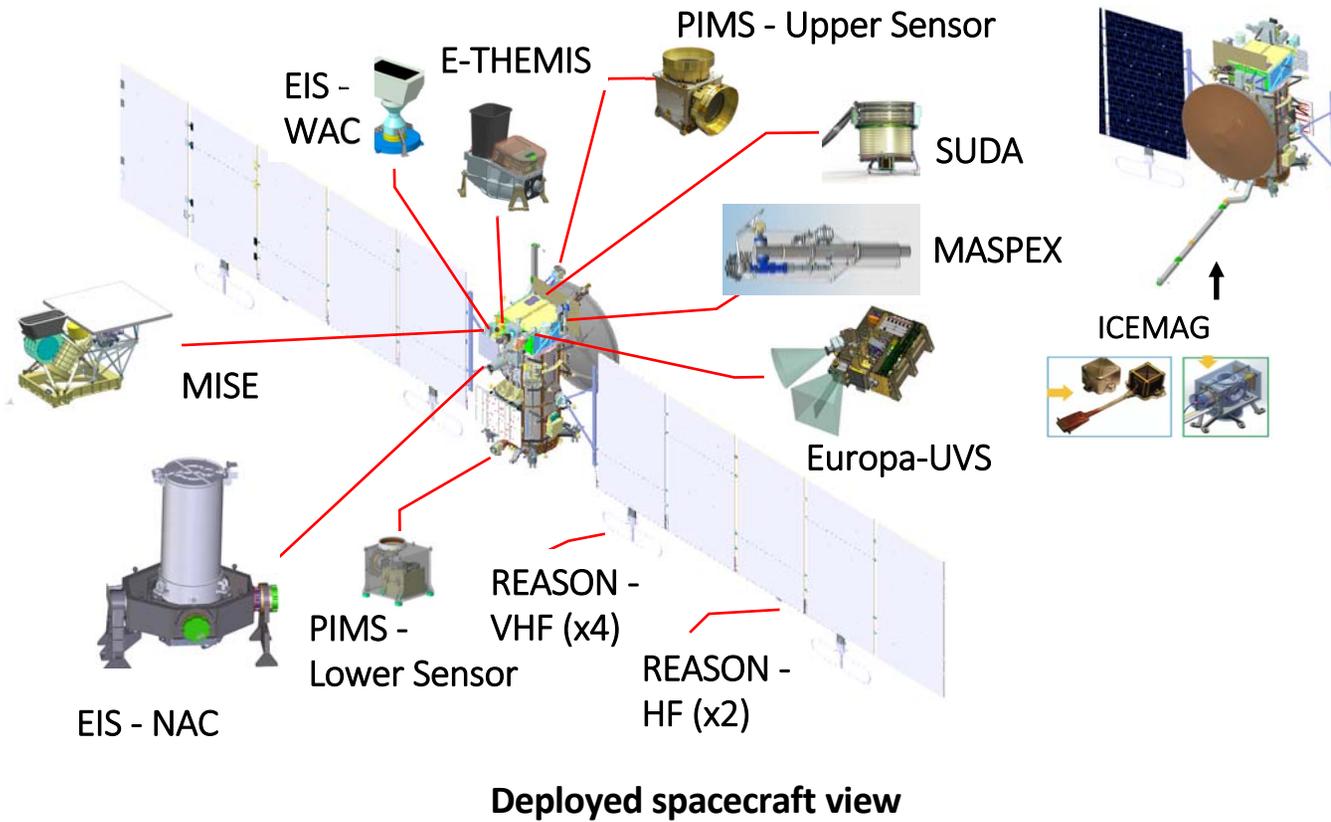


Europa Clipper Flight System Highlights

<p>Power</p>  <p>102 m² Solar array, 339 Ahr Li-Ion batteries, Power regulation, switching & distribution</p>	<p>Avionics</p>  <p>RAD-750 Processor, 512 Gbit non-volatile NAND memory storage, Remote electronics unit, 1553 bus, Spacewire i/Fs, flight software</p>	<p>Radmon</p>  <p>Engineering radiation monitor</p>
<p>Guidance, Navigation, & Control</p>  <p>3-axis control, pointing and slewing for science, JOI, maneuvers, RW and RCS control using redundant SRUs, IMUs, & sun sensors, SA control</p>	<p>Propulsion</p>  <p>Bi-prop system, tanks, lines, 24 engines,</p>	<p>Telecom</p>  <p>RF module, antennas, TWTAs, radios 2-way X band, Ka-band downlink</p>
<p>Thermal</p>  <p>Heat Reclamation System (pumps, lines), radiator, louvers, blankets, heaters,</p>	<p>Science Instruments</p> <p>10 remote sensing and in-situ science instruments hosted & accommodated</p>	<p>Mechanical</p>  <p>Structures, magboom, sensor deck, vault</p>



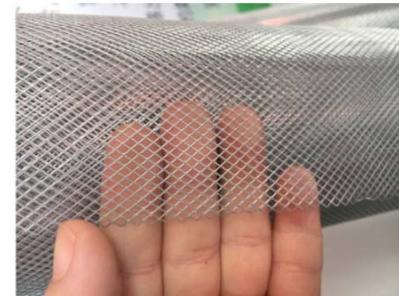
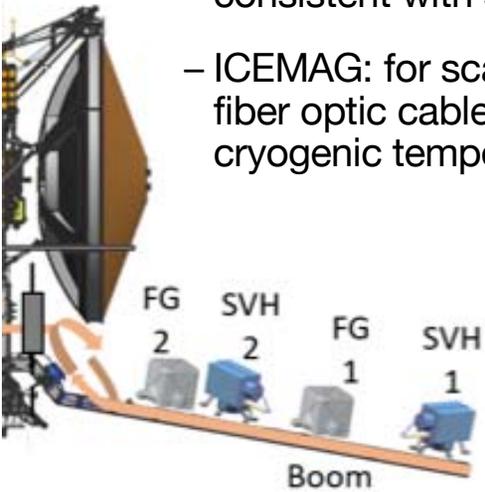
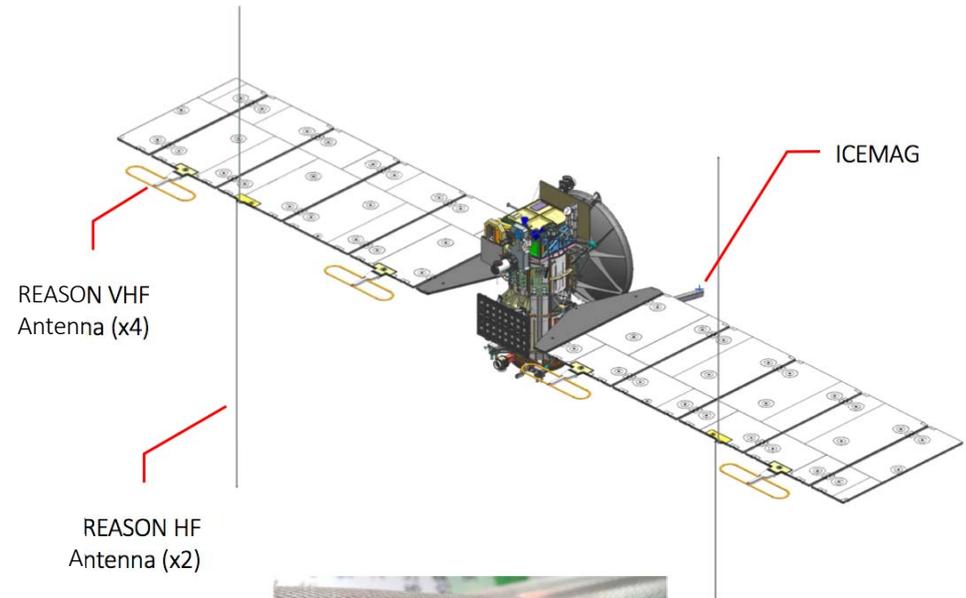
Flight System Instrument Accommodation





Europa Clipper Instrument Accommodation

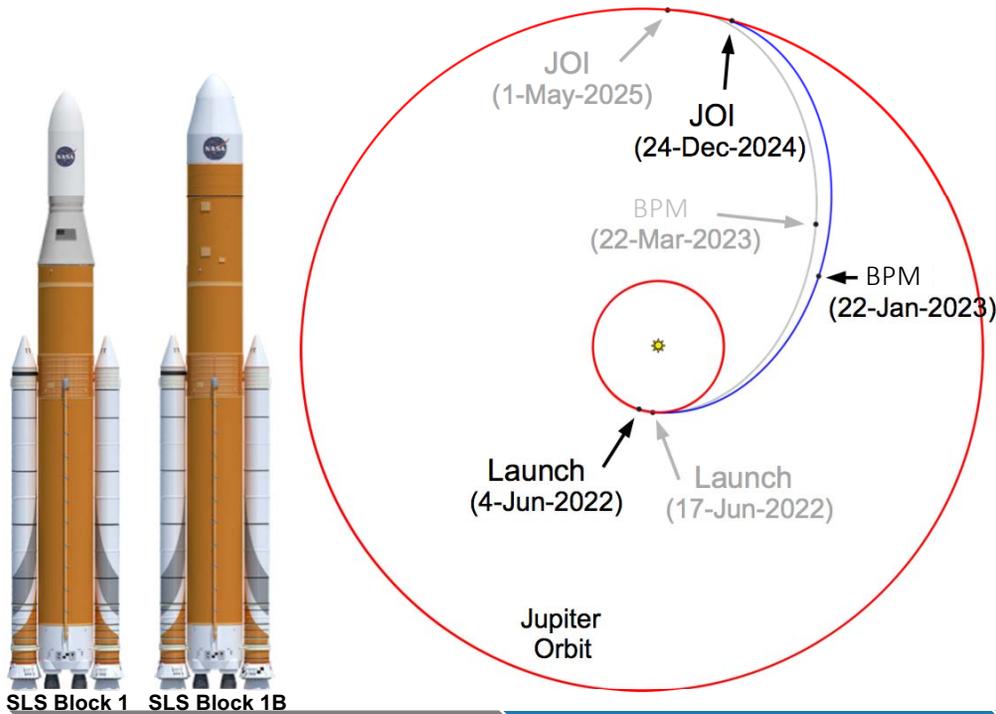
- REASON and ICEMAG accommodation details have been ongoing and challenging, with each now converging on excellent solutions:
 - REASON: converging on solutions for ground plane mesh and coax cable configuration consistent with solar array constraints
 - ICEMAG: for scalar vector helium (SVH) sensors,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



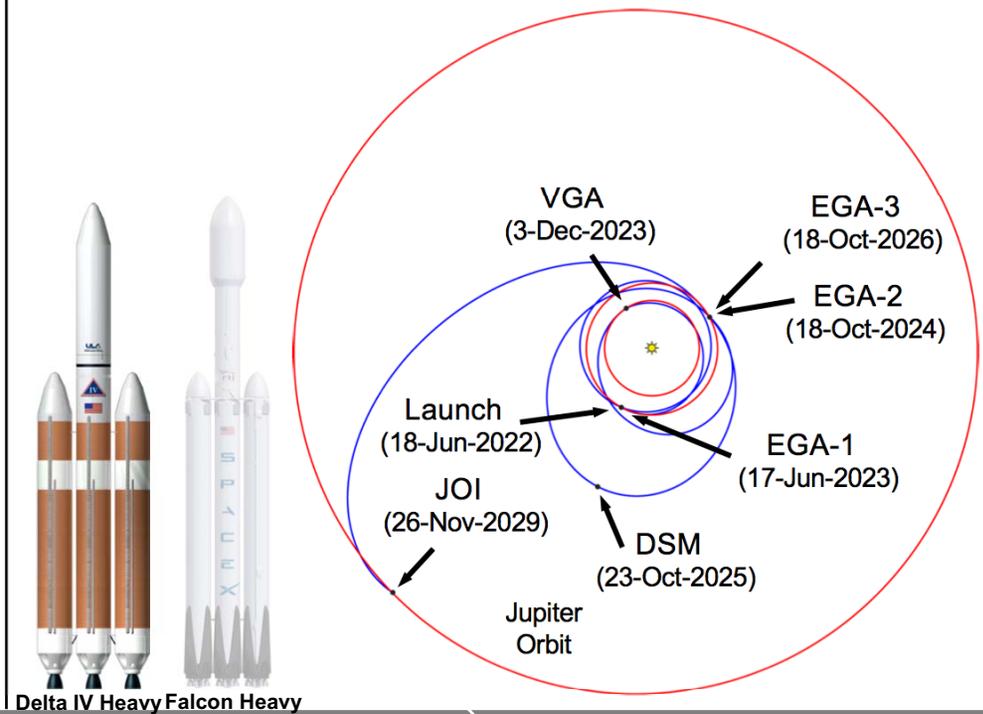


Interplanetary Options (2022 Launch)

Launch Period: 04-Jun-2022 – 24-Jun-2022



Launch Period: 18-Jun-2022 – 08-Jul-2022



Launch

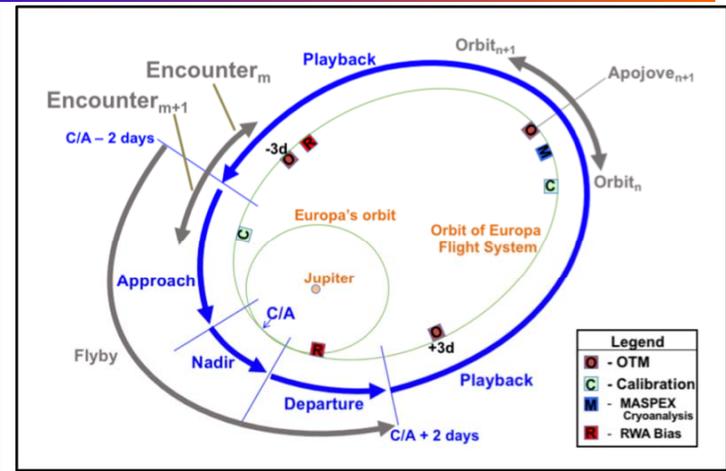
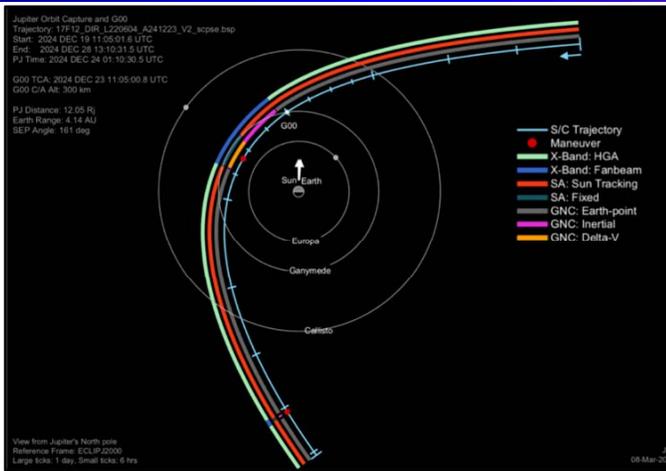
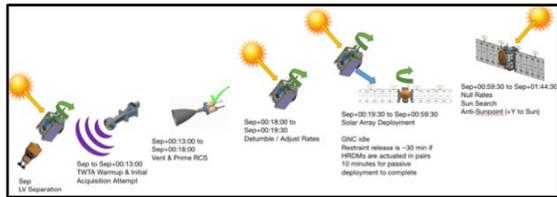
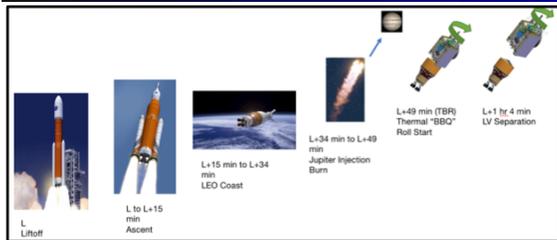
Interplanetary

Jupiter Orbit Capture

Tour



Key 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

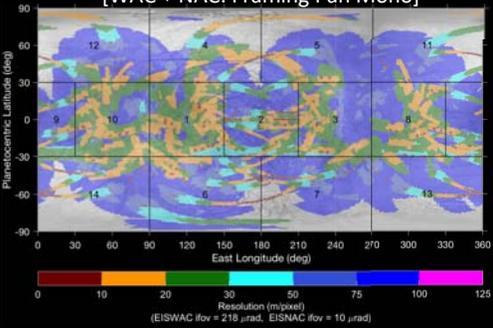
Tour Encounters

- 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

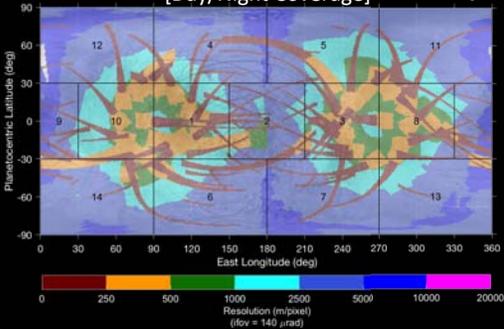
EIS

[WAC + NAC: Framing Pan Mono]

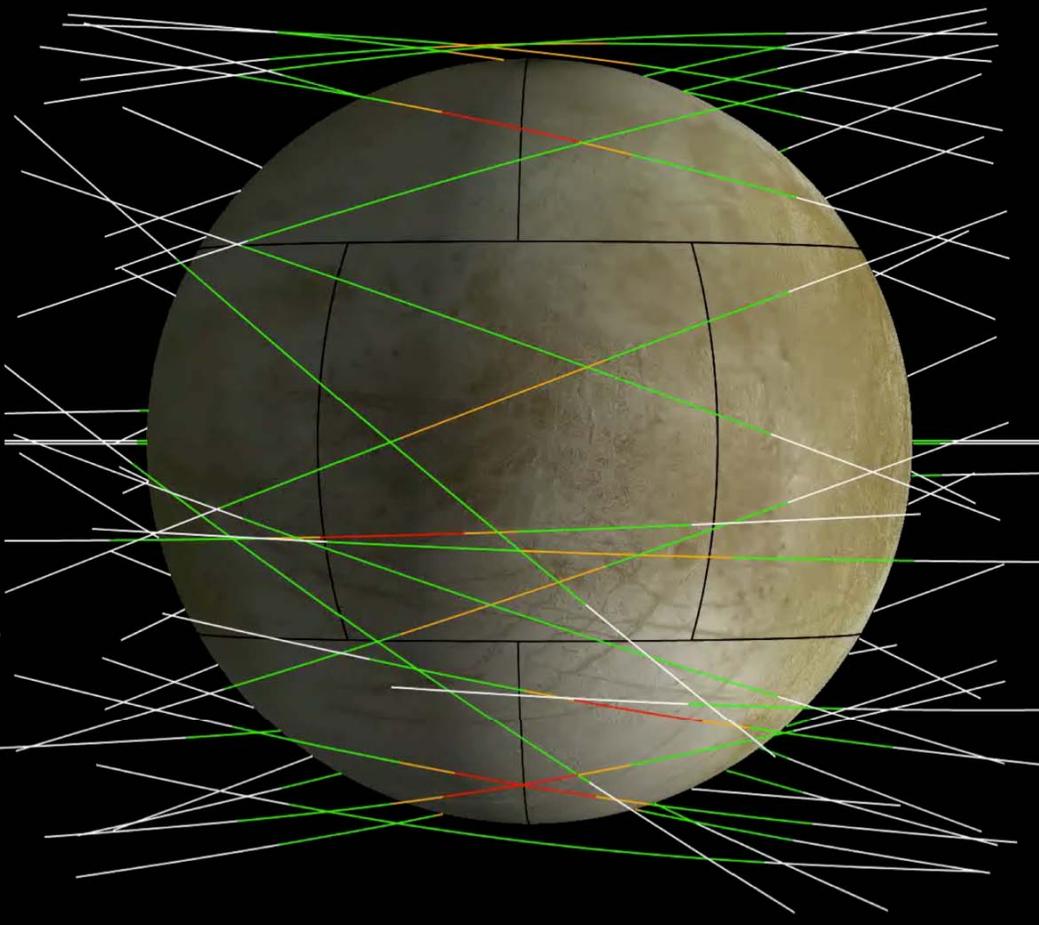
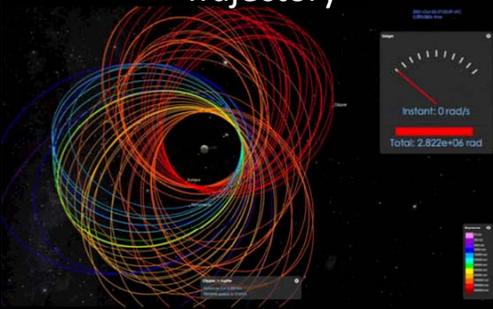


ETHEMIS

[Day/Night Coverage]

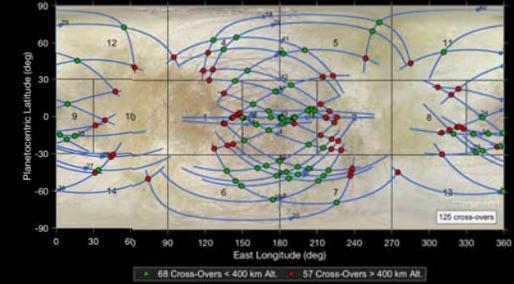


Trajectory



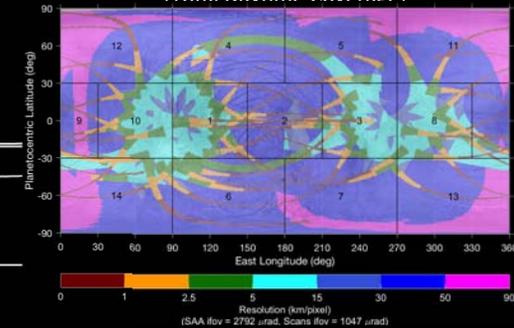
— 25 km ≤ r_{alt} ≤ 50 km — 50 km < r_{alt} ≤ 100 km — 100 km < r_{alt} ≤ 400 km — 400 km < r_{alt} ≤ 1000 km

REASON



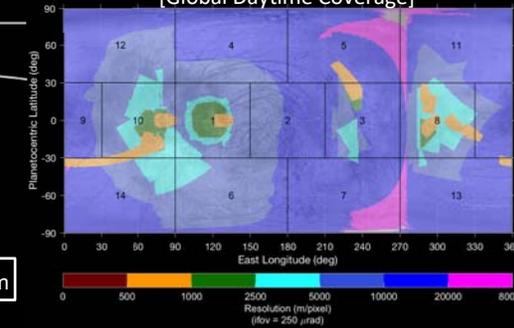
Europa-UVS

[Total Daytime Coverage]



MISE

[Global Daytime Coverage]





Project Science Group Meeting #6

JPL, June 12-14, 2018

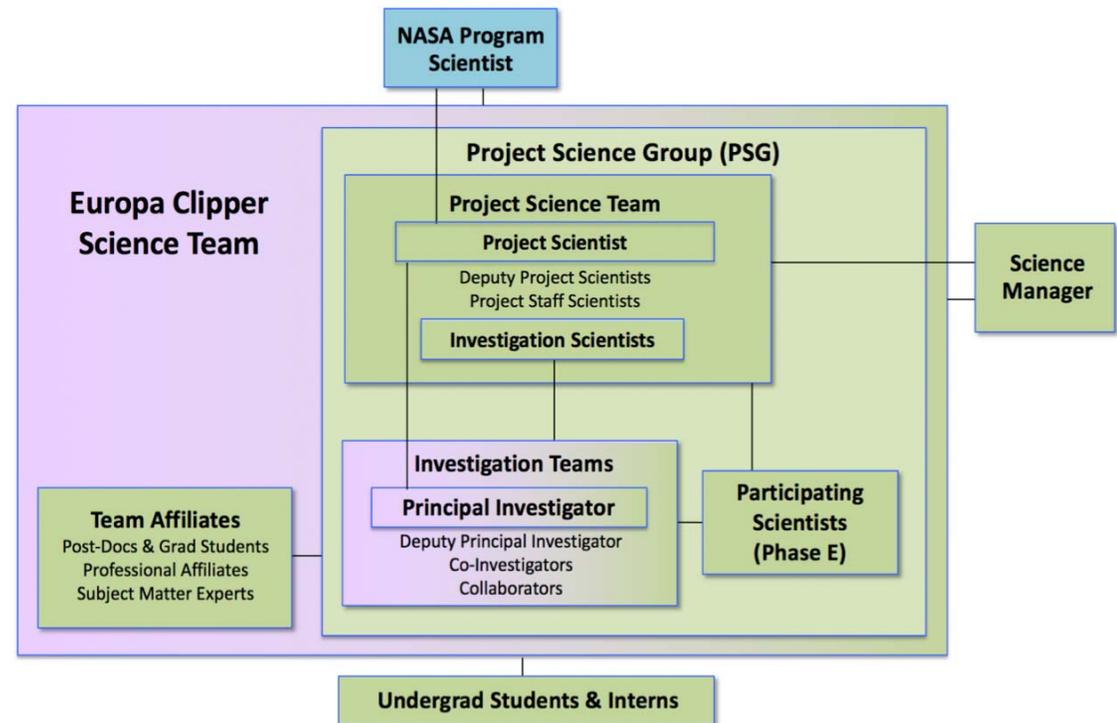
- Built recommendations for the strategic and tactical science planning processes
 - What is the process by which the PSG will generate a strategic plan?
 - What is the process for tactical (encounter-based) planning?
- Discussed circumstances that might suggest deviation from the strategic plan, to 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* MER: *Jeff Moore*
 - Juno: *Candy Hansen* New Horizons: *John Spencer*
 - Cassini: *Bill Kurth*





“One Team” Philosophy

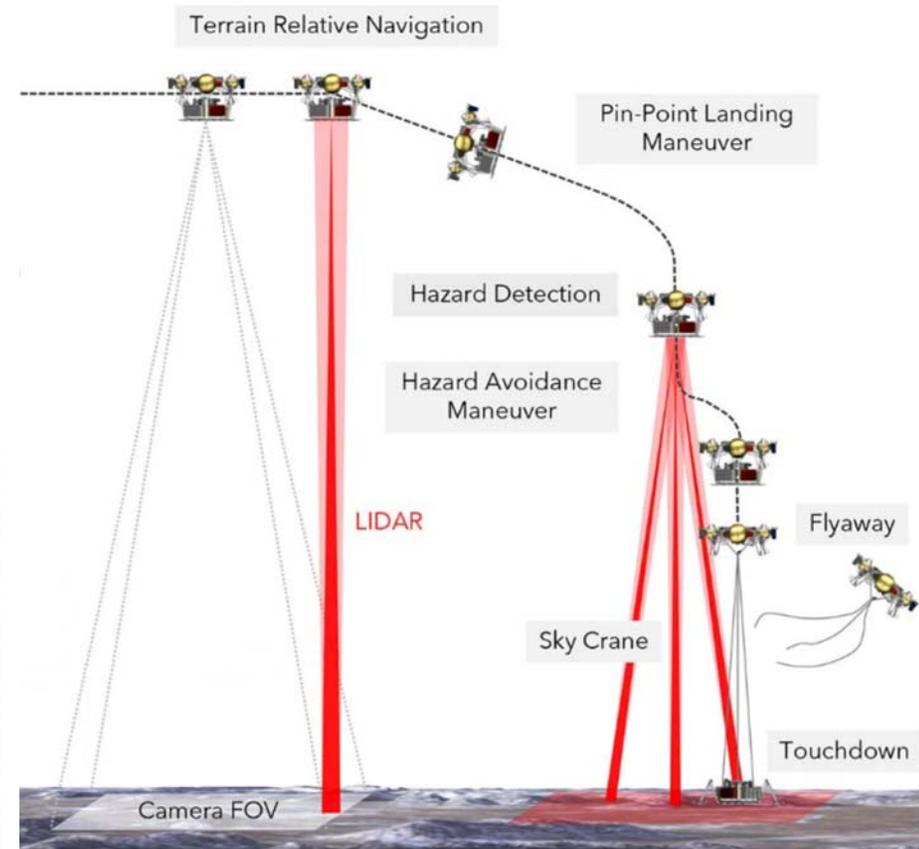
- The Europa Clipper Science Team is one science team
- Fostering integrated science promotes insights and discovery
- The suite of instruments are our common hardware tools
 - Investigation teams are the acknowledged instrument experts
- Shared tools, planning, and data ensure mutual awareness and visibility
- 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





Reconnaissance Focus Group

- Currently joint between Europa Clipper science team and Europa Lander study team
- First meeting was Sept. 10 (yesterday), with goal:
 - Consider strategies for characterization of areas of interest for a potential lander, concentrating on engineering considerations



<https://europa.nasa.gov>

