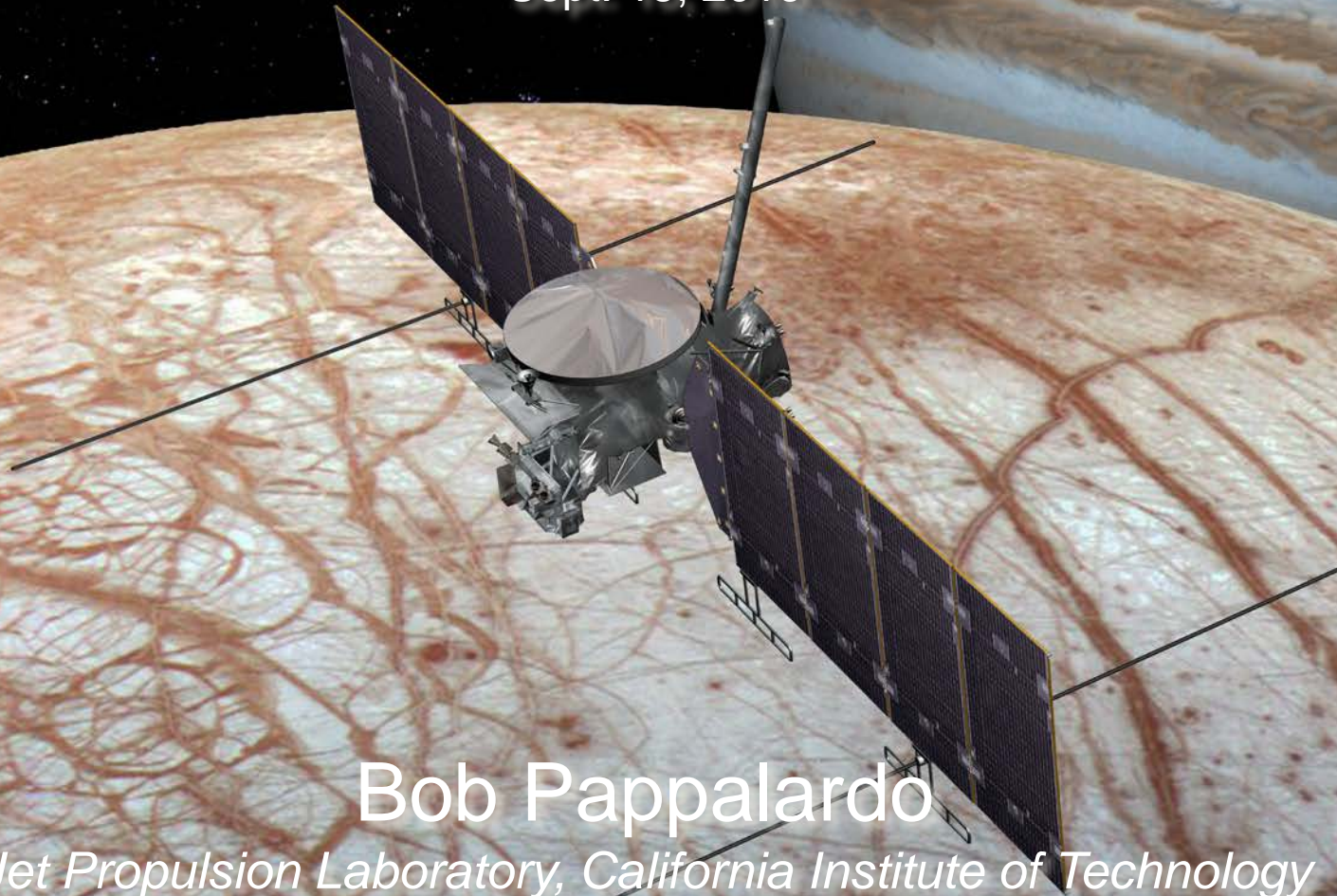




# Europa Multiple Flyby Mission: Update to CAPS

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and the Europa “Clipper” Science Team



# Europa Mission Science Goal:

## *Explore Europa to investigate its habitability*

### Water:

- Probable saltwater ocean, implied by surface geology and magnetic field
- Possible lakes within the ice shell, produced by local melting

### Chemistry:

- Ocean in direct contact with mantle rock, promoting chemical leaching
- Dark red surface materials contain salts, probably from the ocean

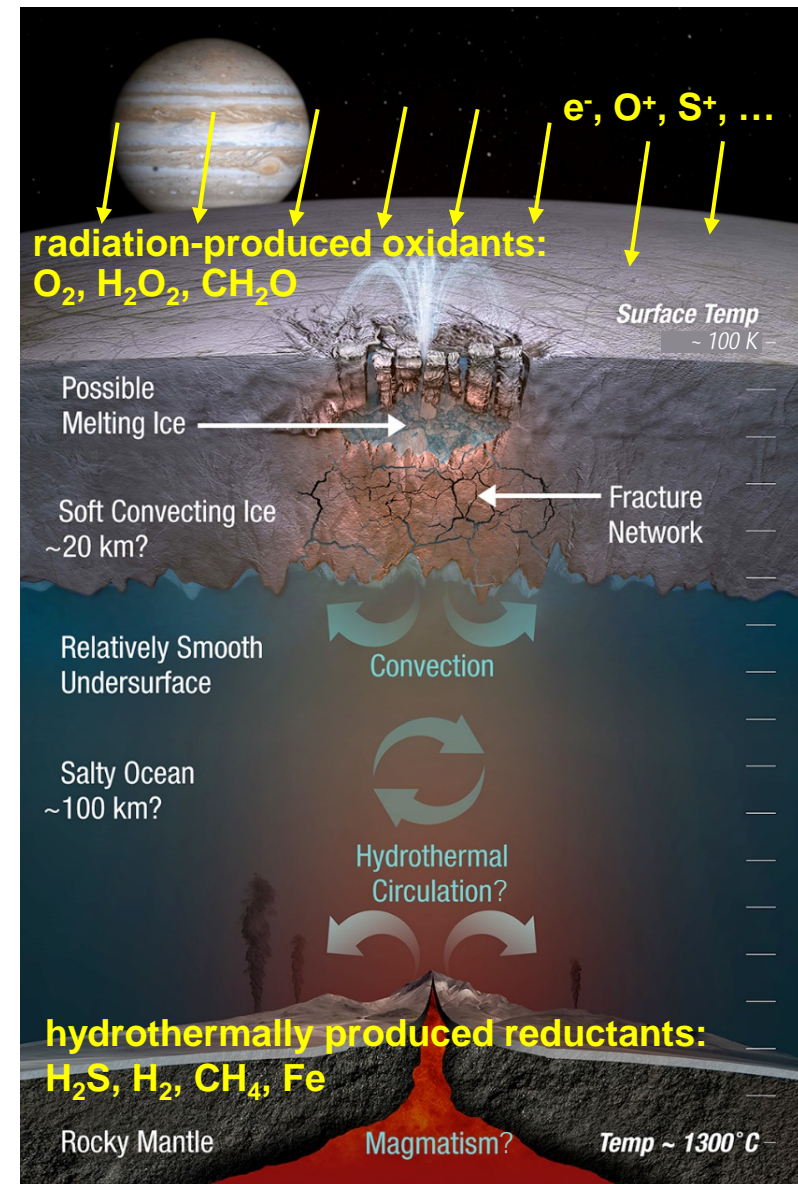
### Energy:

- Chemical energy might sustain life
- Surface irradiation creates oxidants
- Mantle rock-water reactions could create reductants (hydrothermal or serpentinization)

### Activity:

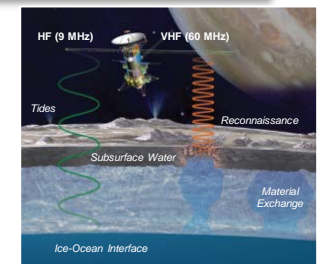
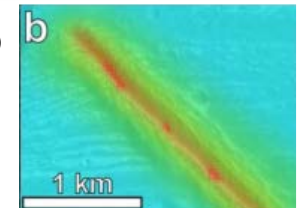
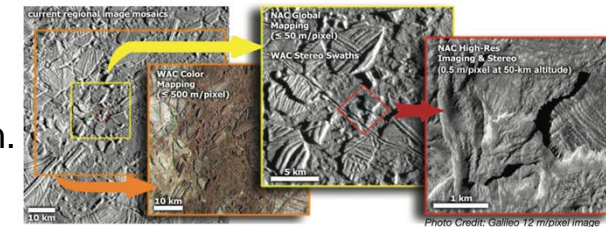
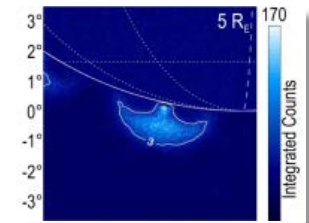
- Geological activity “stirs the pot”
- Activity could be cyclical, as tied to Io

***Europa Flyby Mission will test key habitability hypotheses***



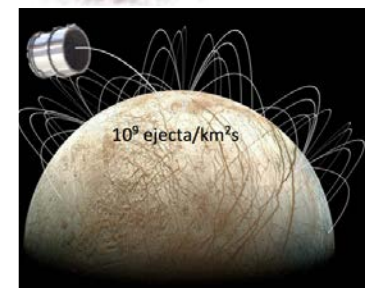
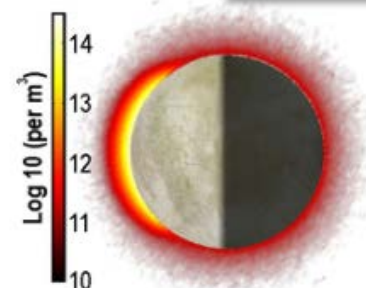
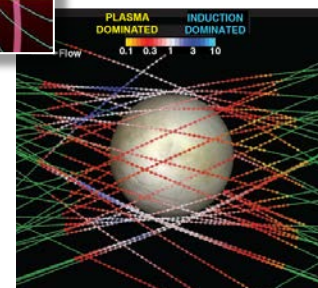
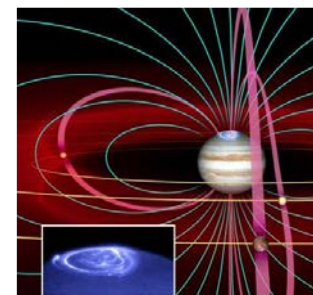
# Europa Remote Sensing Techniques

- **Ultraviolet Spectrograph/Europa (Europa-UVS)** – PI Dr. Kurt Retherford, SwRI, San Antonio
  - Detect possible water plumes erupting from Europa's surface and provide data about the composition and dynamics of Europa's rarefied atmosphere.
- **Europa Imaging System (EIS)** – PI Dr. Elizabeth Turtle, APL
  - Wide and narrow angle cameras to map most of Europa at better than 100 m resolution, with areas up to 100 times higher resolution.
- **Mapping Imaging Spectrometer for Europa (MISE)**
  - PI Dr. Diana Blaney, JPL
    - Probe Europa's composition, identifying and mapping distributions of organics, salts, acid hydrates, ices, and other materials to determine habitability of Europa's ocean.
- **Europa Thermal Emission Imaging System (E-THEMIS)** – PI Dr. Philip Christensen, Arizona State University, Tempe
  - Provide multi-spectral thermal imaging of Europa to help detect active sites, such as potential vents erupting plumes of water into space.
- **Radar for Europa Assessment and Sounding: Ocean to Near-surface (REASON)** – PI Dr. Donald Blankenship, University of Texas, Austin
  - Characterize and sound Europa's icy crust from the near-surface to the ocean, revealing hidden structures and potential water within.



# Europa *In Situ* Techniques

- **Interior Characterization of Europa using Magnetometry (ICEMAG)** – PI Dr. Carol Raymond, JPL
  - Magnetometer to measure the magnetic field near Europa and infer the location, thickness and salinity of Europa's subsurface ocean using multi-frequency electromagnetic sounding.
- **Plasma Instrument for Magnetic Sounding (PIMS)** – PI Dr. Joseph Westlake, APL, Laurel, Maryland
  - In conjunction with a magnetometer, is key to determining Europa's ice shell thickness, ocean depth, and salinity by correcting the magnetic induction signal for plasma currents around Europa.
- **MAss SPectrometer for Planetary EXploration/Europa (MASPEX)** – PI Dr. Jack (Hunter) Waite, SwRI, San Antonio
  - To determine the composition of the surface and subsurface ocean by measuring Europa's extremely tenuous atmosphere and any surface material ejected into space.
- **SURface Dust Mass Analyzer (SUDA)** – PI Dr. Sascha Kempf, University of Colorado, Boulder
  - To measure the composition of small, solid particles ejected from Europa, providing the opportunity to directly sample the surface and potential plumes on low-altitude flybys.





# Europa Mission Science Objectives (1/3): ***Ice Shell & Ocean***

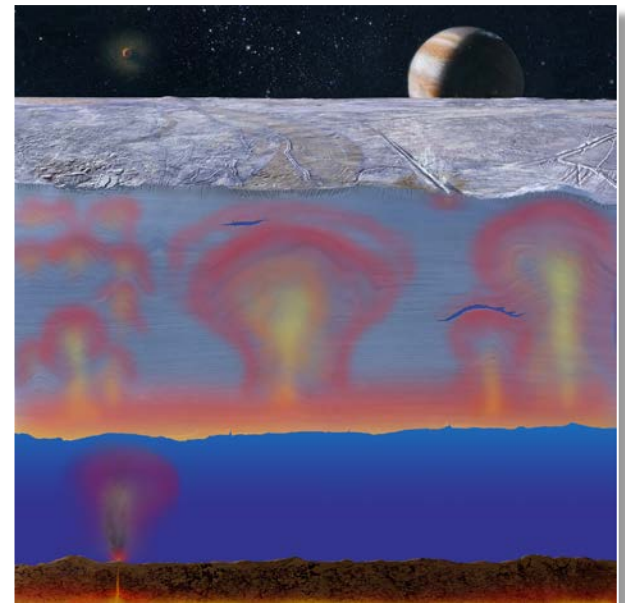
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- ***Ice Shell & Ocean Objective:***

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

- ***Ice Shell & Ocean Investigations:***

- Characterize the distribution of any shallow subsurface water and the structure of the icy shell [*EIS, REASON*]
- Determine ocean salinity and thickness [*ICEMAG, MISE, PIMS, SUDA*]
- Constrain the regional and global thickness, heat-flow, and dynamics of the ice shell [*E-THEMIS, EIS, Gravity, ICEMAG, PIMS, REASON*]
- Investigate processes governing material exchange among the ocean, ice shell, surface, and atmosphere [*EIS, ICEMAG, MASPEX, MISE, REASON, SUDA*]



# Europa Mission Science Objectives (2/3): *Composition*

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- ***Composition Objective:***

Understand the habitability of Europa's ocean through composition and chemistry

- ***Composition Investigations:***

- Characterize the composition and chemistry of endogenic materials on the surface and in the atmosphere, including potential plumes  
[EIS, Europa-UVS, ICEMAG, MASPEX, MISE, PIMS, REASON, SUDA]
- Determine the role of the radiation and plasma environment in creating and processing the atmosphere and surface materials  
[EIS, Europa-UVS, MASPEX, MISE, PIMS, Radiation, REASON, SUDA]
- Characterize the chemical and compositional pathways in the ocean  
[EIS, ICEMAG, MASPEX, MISE, SUDA]



# Europa Mission Science Objectives (3/3): *Geology*

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- ***Geology Objective:***

Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities

- ***Geology Investigations:***

- Determine sites of most recent geological activity, including potential plumes, and characterize localities of high science interest and potential future landing sites [*E-THEMIS, EIS, Europa-UVS, MASPEX, MISE, PIMS, Radiation, REASON, SUDA*]
- Determine the formation and three-dimensional characteristics of magmatic, tectonic, and impact landforms [*EIS, REASON*]
- Investigate processes of erosion and deposition and their effects on the physical properties of the surface [*E-THEMIS, EIS, Europa-UVS, PIMS, Radiation, REASON, SUDA*]





# Europa Mission Concept

- Ensure capability for collecting synergistic data from all instruments (nadir-pointed, ram-pointed) simultaneously and during each flyby
  - Maximizes science return by facilitating in-depth multi-instrument interpretations
  - Minimizes data collection time in the high-radiation environment
  - Enables simple, repeatable operations

16 m radar HF  
Antenna (2x)

Magnetometer boom  
5 m

Solar Panels  
2.2 m x 4.1 m each

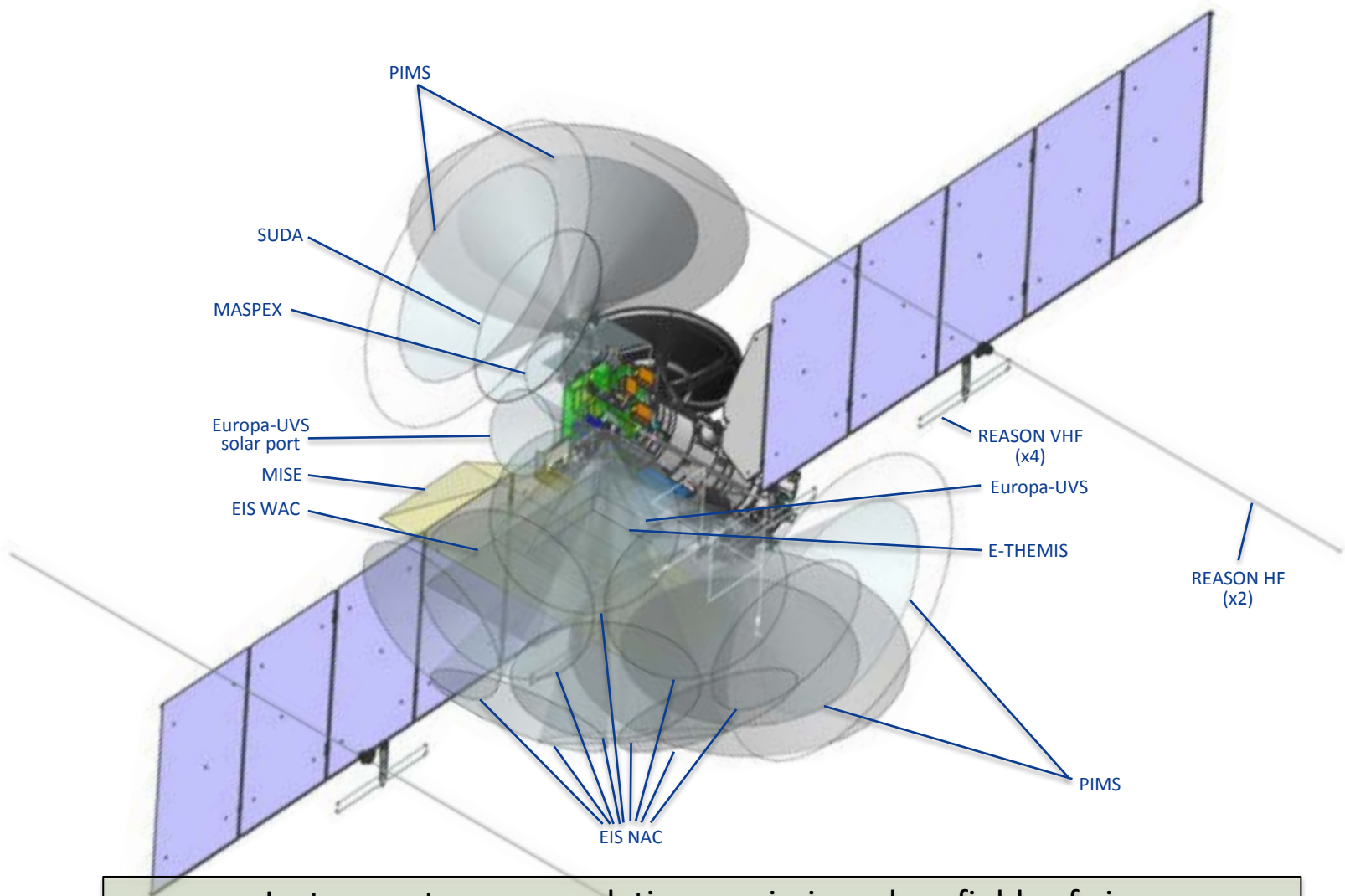
Forward-pointing  
*in situ* instruments

Downward-pointing  
remote sensing  
instruments

Radar VHF  
Antennas (4x)



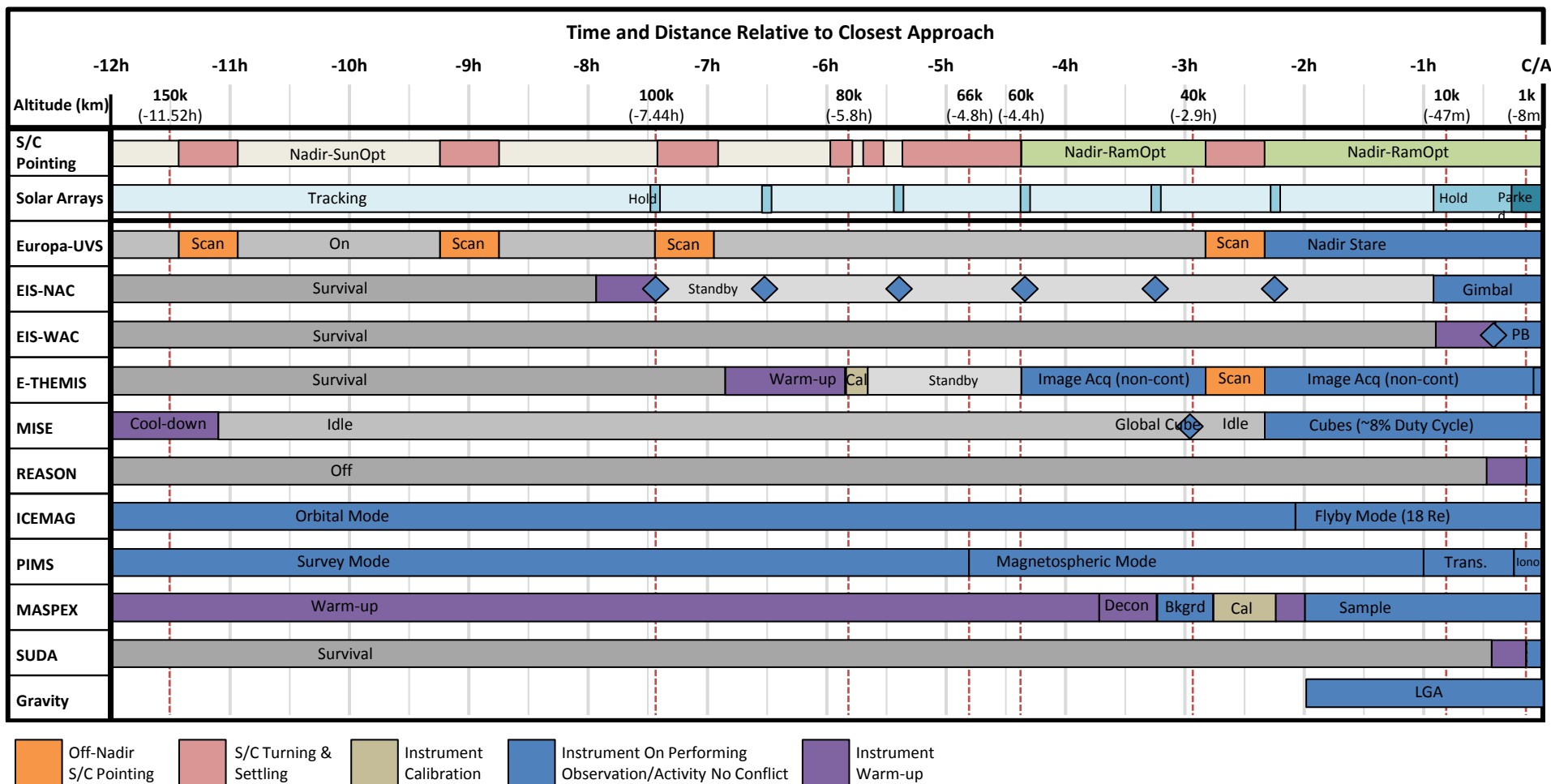
# Instrument Accommodation



Instrument accommodation maximizes clear fields of view and permits simultaneity of instrument observations.

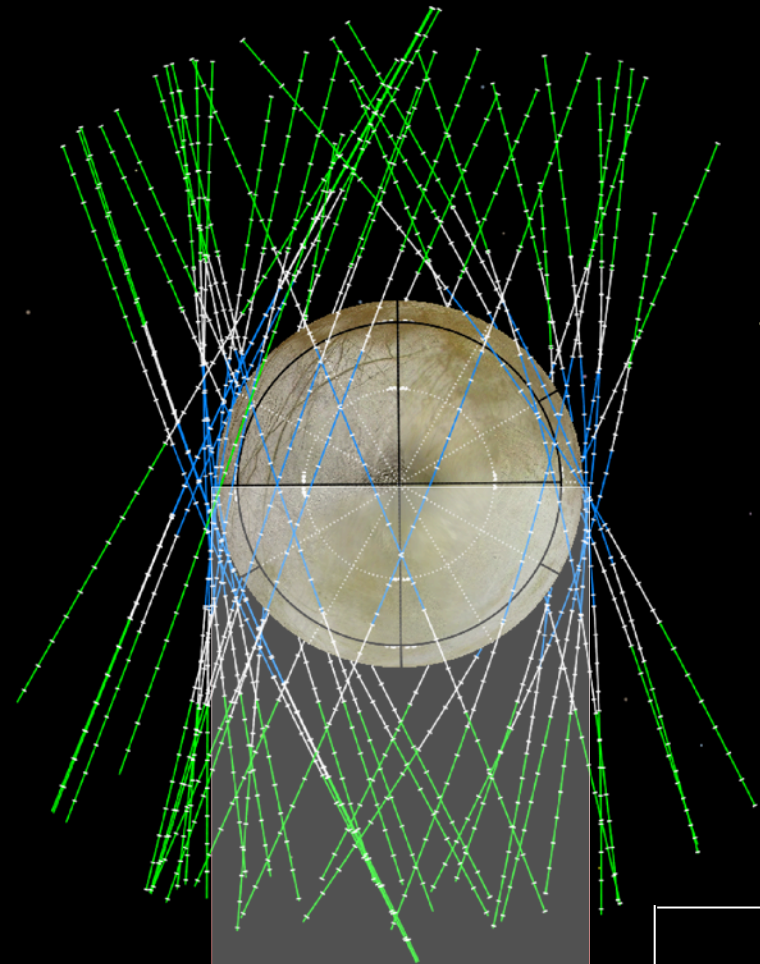
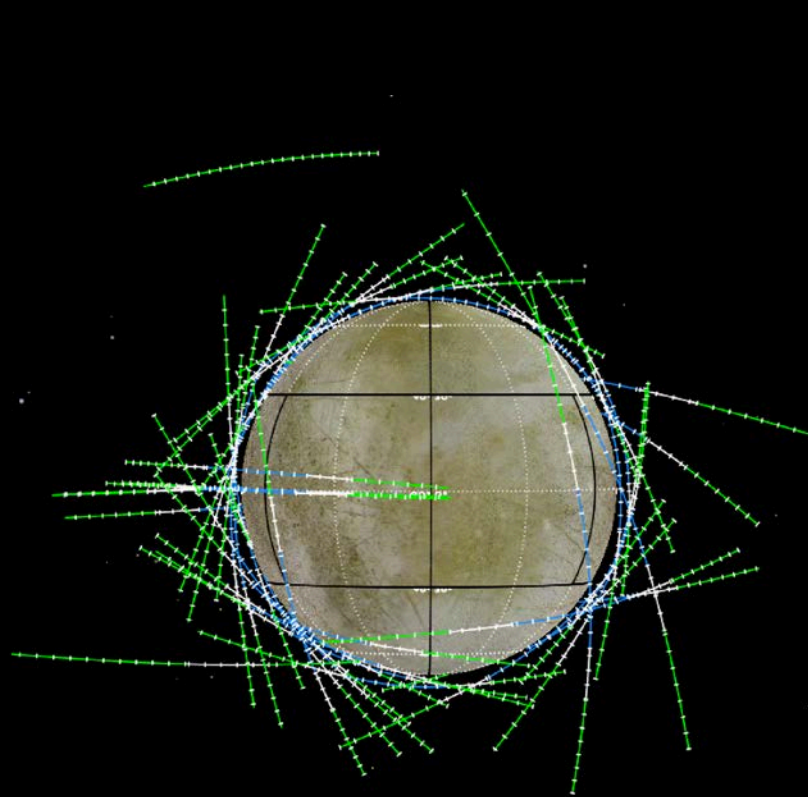
# Concept of Operations: Simple & Repeatable

- Occasional spacecraft scanning for distant observations and calibrations (>34,000 km)
- Nadir-pointed orientation during flyby period (within  $\pm 34,000$  km)
- Solar panels parked for up to an hour bracketing closest approach (REASON, NAC)





# Trajectory Development (16F11)



Europa  
North

↑

→ Jupiter

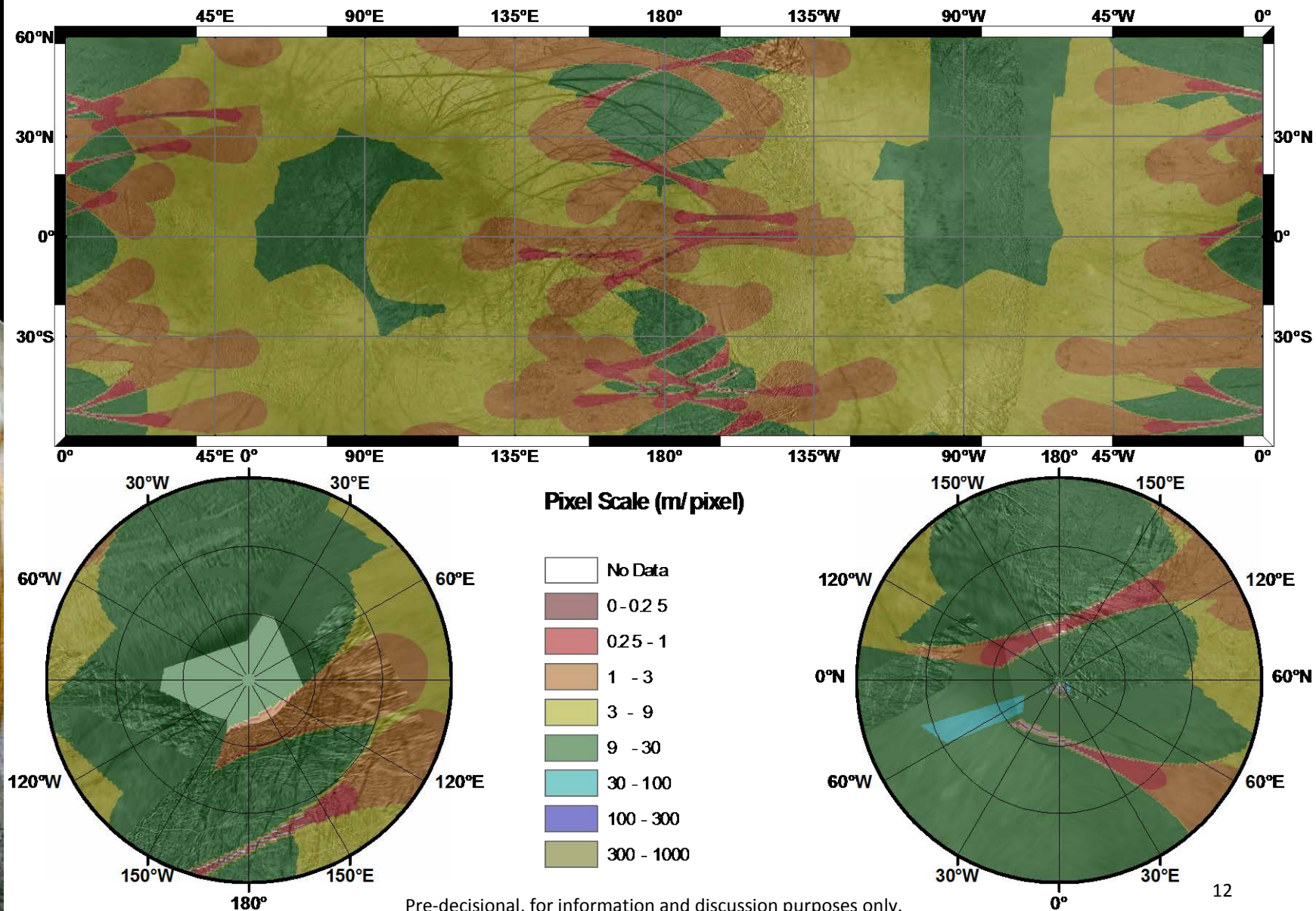
Altitude  
Alt.  $\leq 400$  km  
 $400 \leq \text{Alt} \leq 1000$  km  
 $1000 \leq \text{Alt} \leq 2500$  km

→ Jupiter

↓ Europa  
Velocity

# Europa Mission Imaging Potential

## Europa Imaging System Narrow Angle Camera







<http://www.nasa.gov/europa>