EUROPA

Science Update to OPAG

Aug. 11, 2016

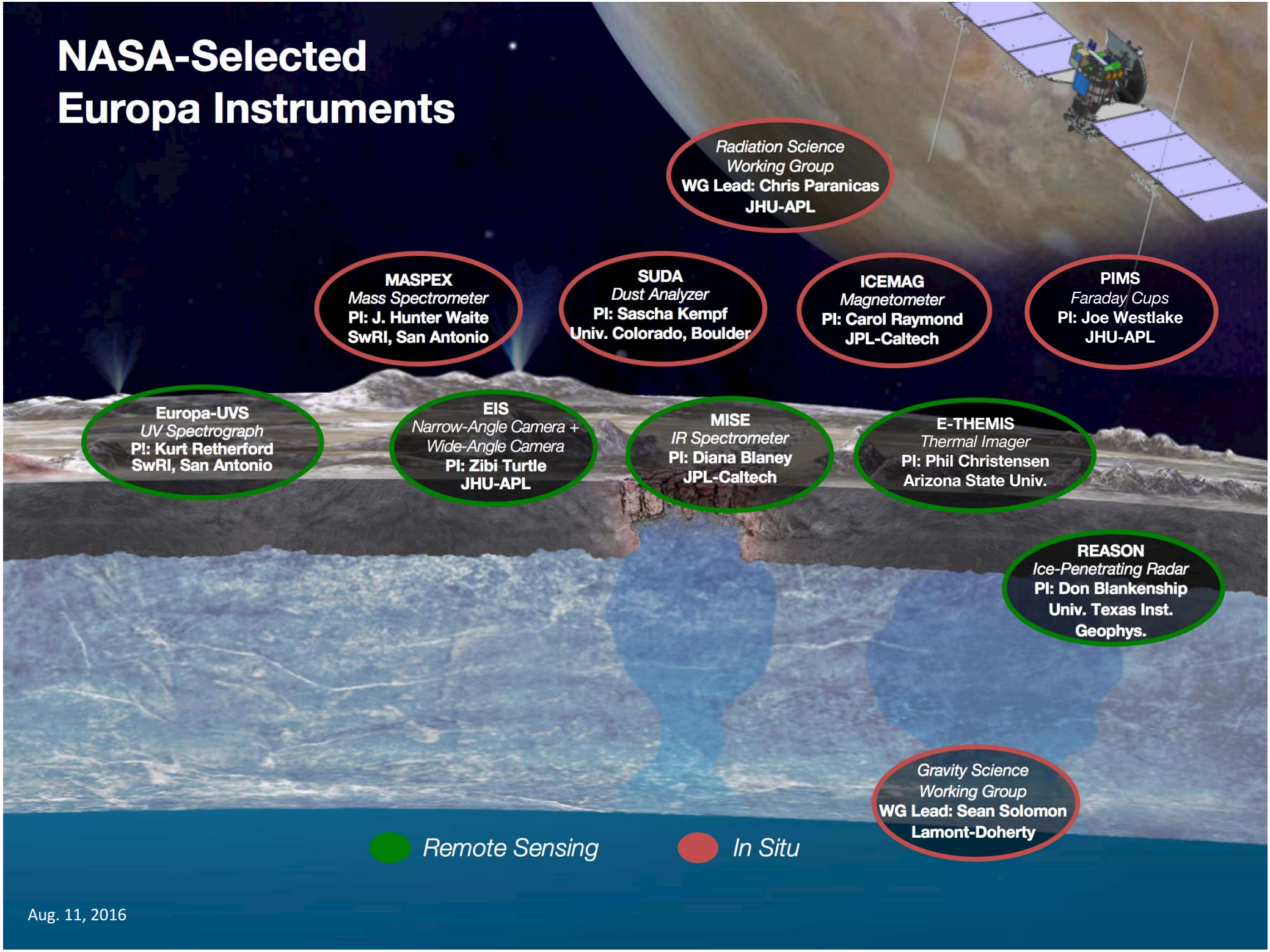
Bob Pappalardo

Europa Project Scientist, Jet Propulsion Laboratory, California Institute of Technology

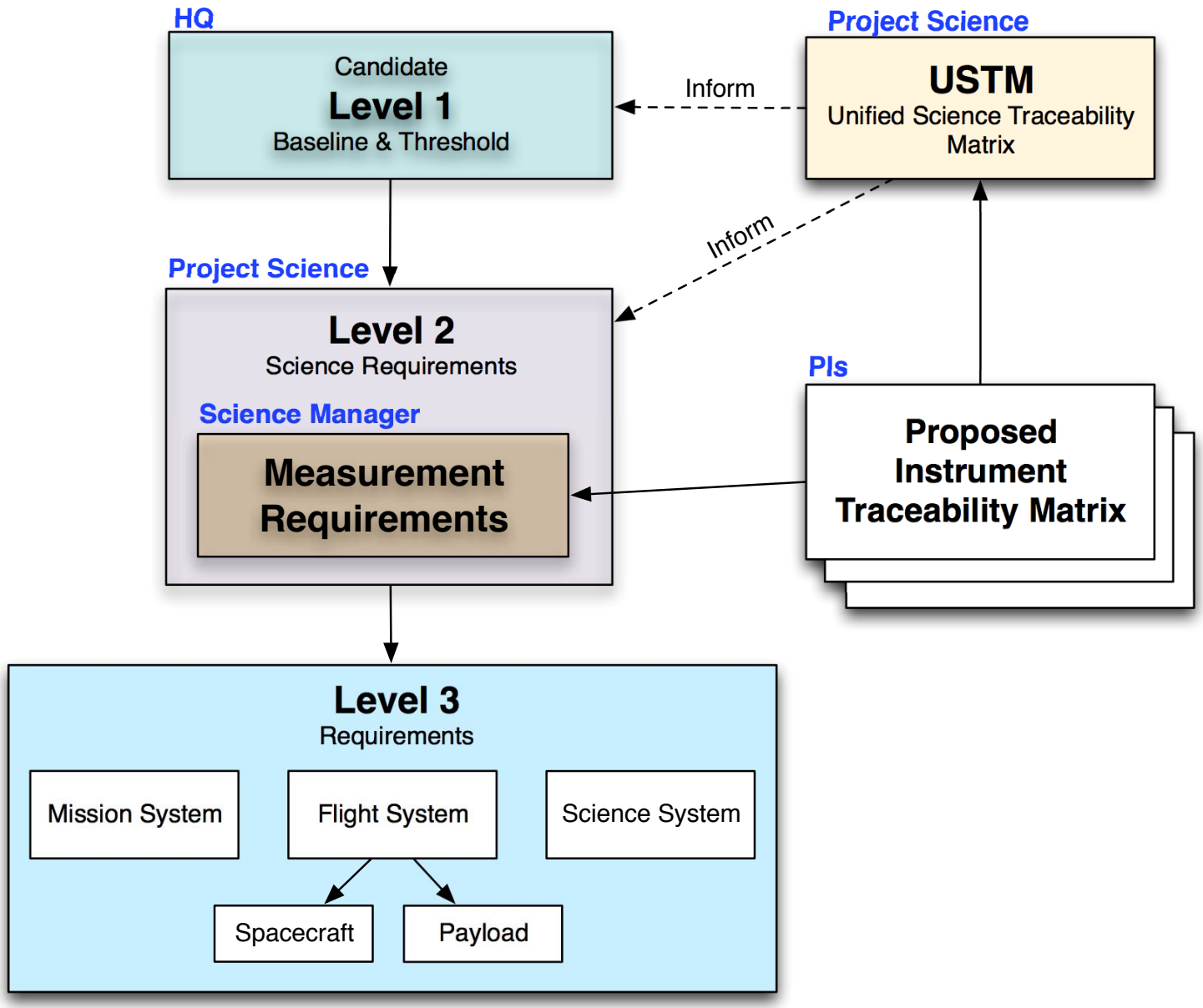
© 2016 California Institute of Technology. Government sponsorship acknowledged.

Europa Science Update: Topics

1. Science requirements status
2. Instrument accommodation
3. Updated concept of operations
4. Trajectory development
5. Addressing the ladder of life
6. Altimetry for ocean detection
7. Europa Science Team news


NASA-Selected
Europa Instruments
Radiation Science
Working Group
WG Lead: Chris Paranicas
JHU-APL
MASPEX
Mass Spectrometer
PI: J. Hunter Waite
SwRI, San Antonio
SUDA
Dust Analyzer
PI: Sascha Kempf
Univ. Colorado, Boulder
ICEMAG
Magnetometer
PI: Carol Raymond
JPL-Caltech
PIMS
Faraday Cups
PI: Joe Westlake
JHU-APL
Europa-UVS
UV Spectrograph
PI: Kurt Retherford
SwRI, San Antonio
EIS
Narrow-Angle Camera +
Wide-Angle Camera
PI: Zibi Turtle
JHU-APL
MISE
IR Spectrometer
PI: Diana Blaney
JPL-Caltech
E-THEMIS
Thermal Imager
PI: Phil Christensen
Arizona State Univ.
REASON
Ice-Penetrating Radar
PI: Don Blankenship
Univ. Texas Inst.
Geophys.
Gravity Science
Working Group
WG Lead: Sean Solomon
Lamont-Doherty
Remote Sensing
In Situ
Aug. 11, 2016

1. Science Requirements Status



Candidate Level 1 Science Requirements

	Baseline Level-1	Threshold Level-1	REASON HF	REASON VHF	EIS NAC	EIS WAC	MISE	E-THEMIS	Europa-UVS	ICEMAG	PIMS	SUDA	MASPEX	Gravity + Altimetry
Ice/Ocean	Subsurface struct. (≥50 landforms)	Subsurface struct. (≥15 landforms)												
	Ice shell thickness (±50%)	Confirm ocean / thick vs. thin shell	*											*
Composition	Global comp. (≥70% coverage)	Global comp. (≥40% coverage)												
	Landform comp. (≥50, ≤300 m)	Landform comp. (≥15, ≤25 km)												
	Gas, dust, and plasma comp.	Gas or dust composition												
Geology	Global imaging (≥80% coverage)	Global imaging (≥30% coverage)												
	High-res (≤25m) landforms (≥50)	High-res (≤50m) landforms (≥15)												
	Local surface (~1m, ≥40 sites)	*[None]*												
Activity	Characterize current activity	Search for current activity												

Key instrument (achieves requirement)

Supportive instrument (enhances the science)

Baseline

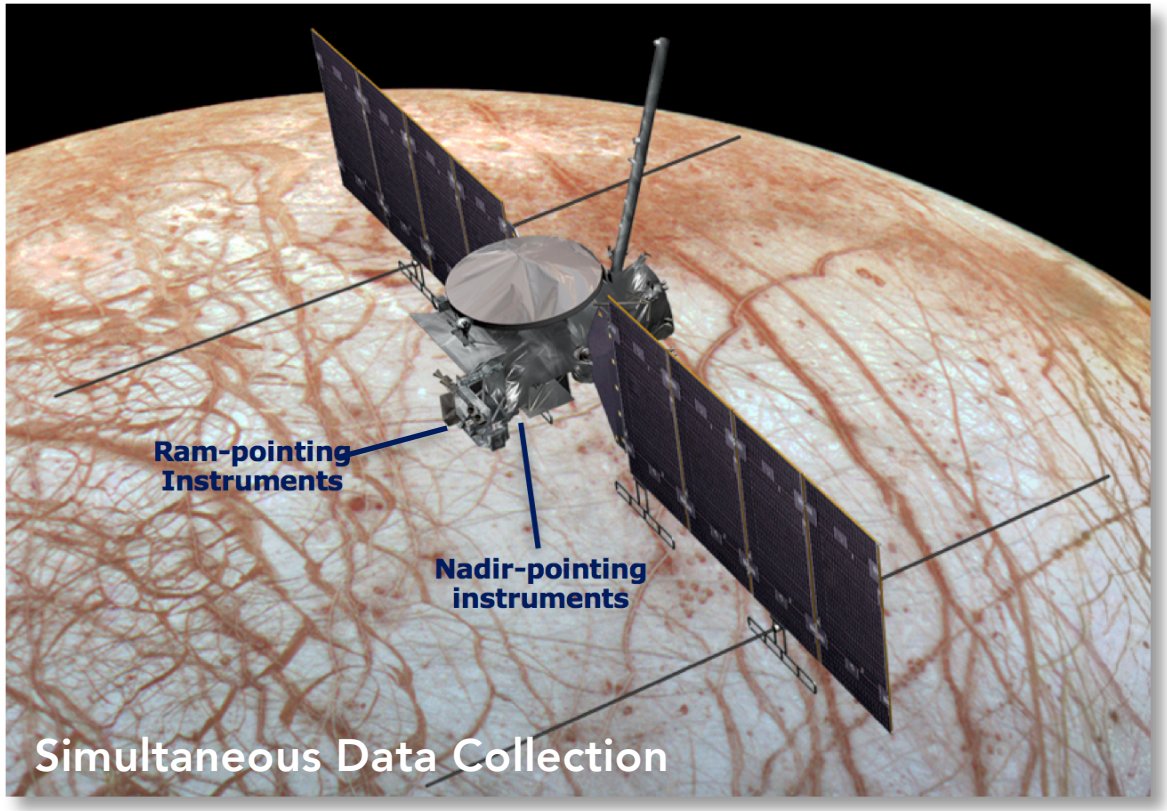
Threshold

*** In combination achieves threshold**

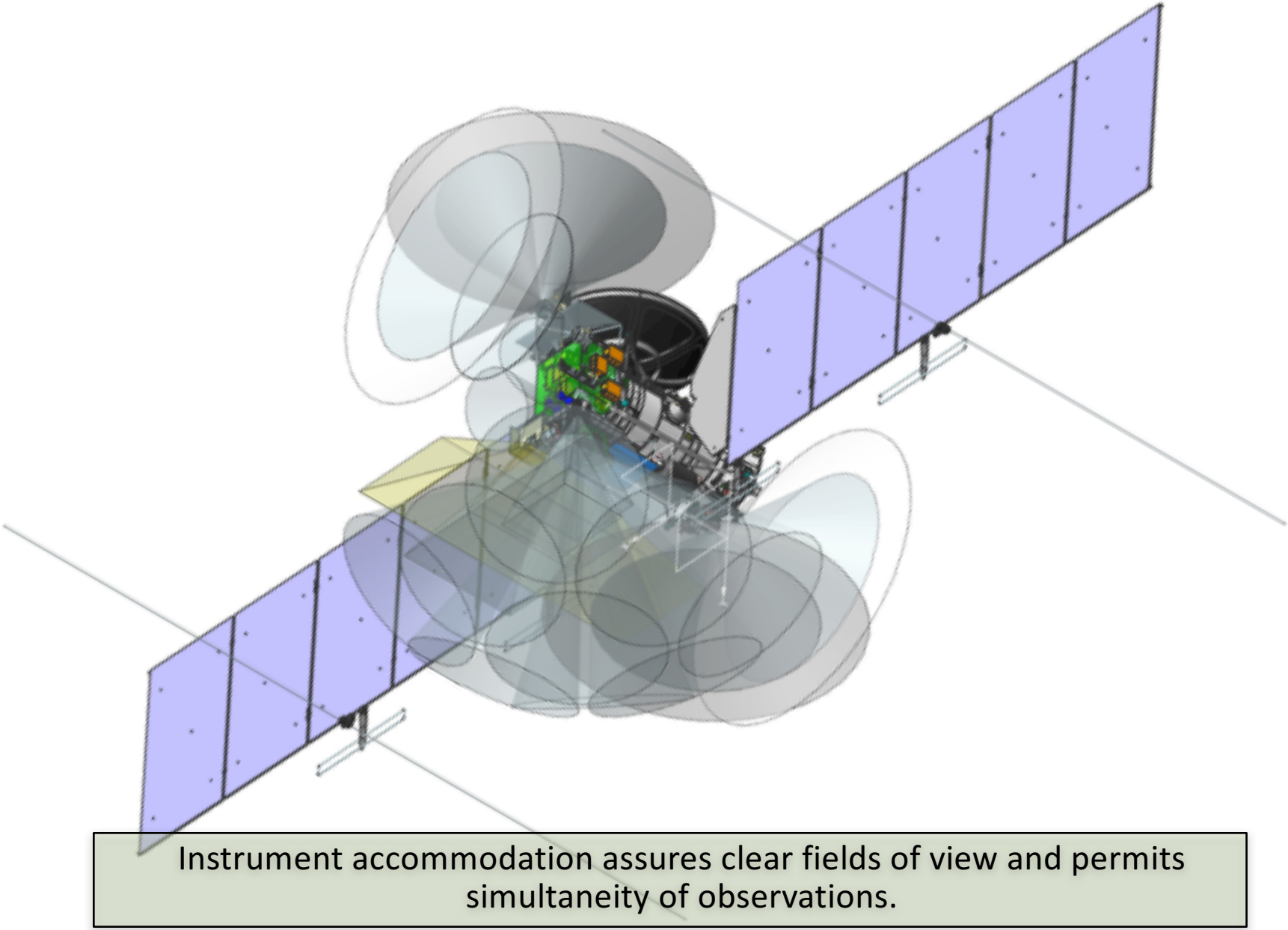
- Instruments work synergistically to achieve the science requirements
- Threshold science can be achieved through multiple techniques

2. Instrument Accommodation

- Ensure capability for obtaining synergistic data from all instruments (nadir-pointed, ram-pointed, and gravity science) 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



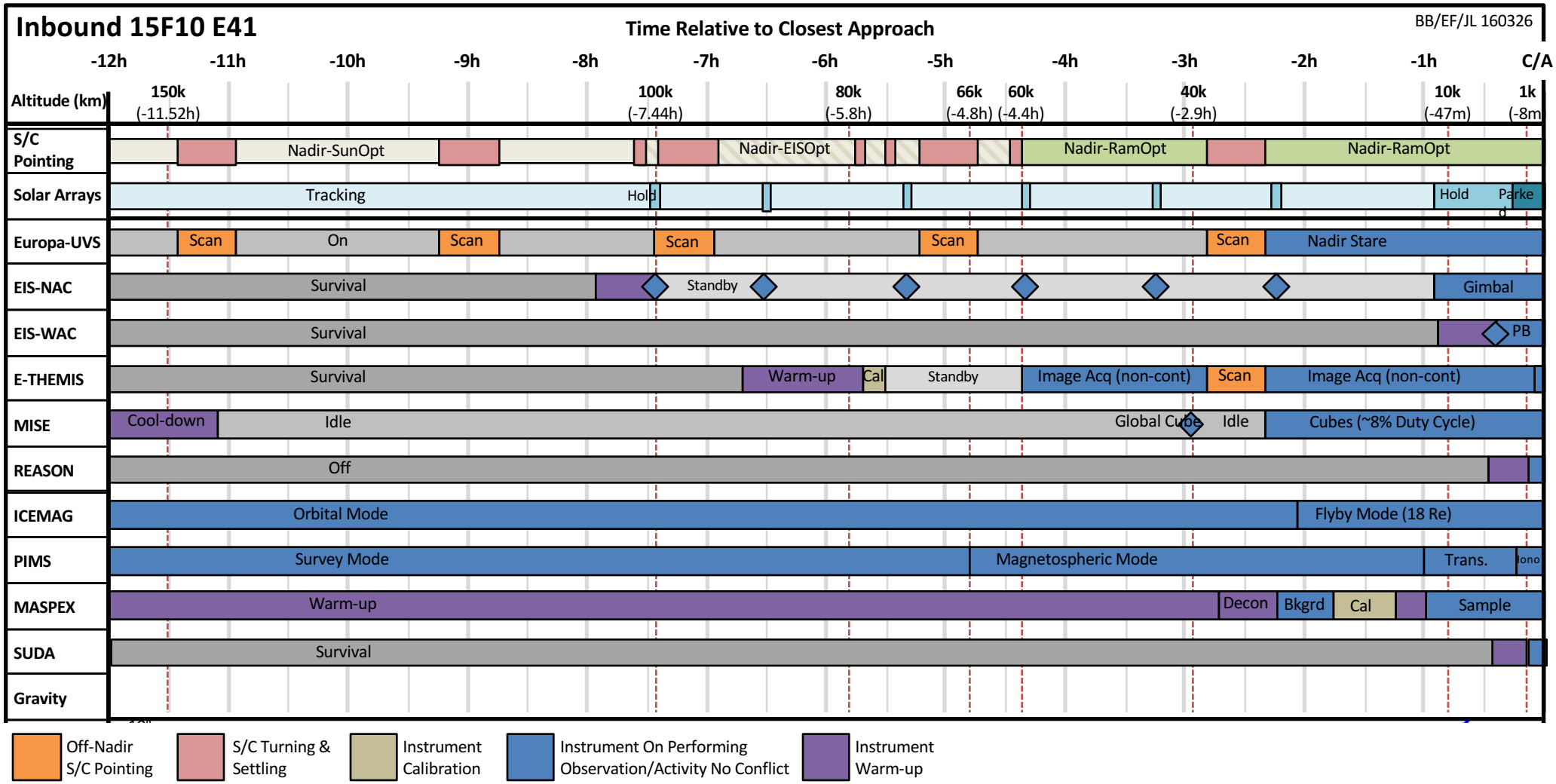
Instrument Fields of View



Instrument accommodation assures clear fields of view and permits simultaneity of observations.

3. Concept of Operations: Simple & Repeatable

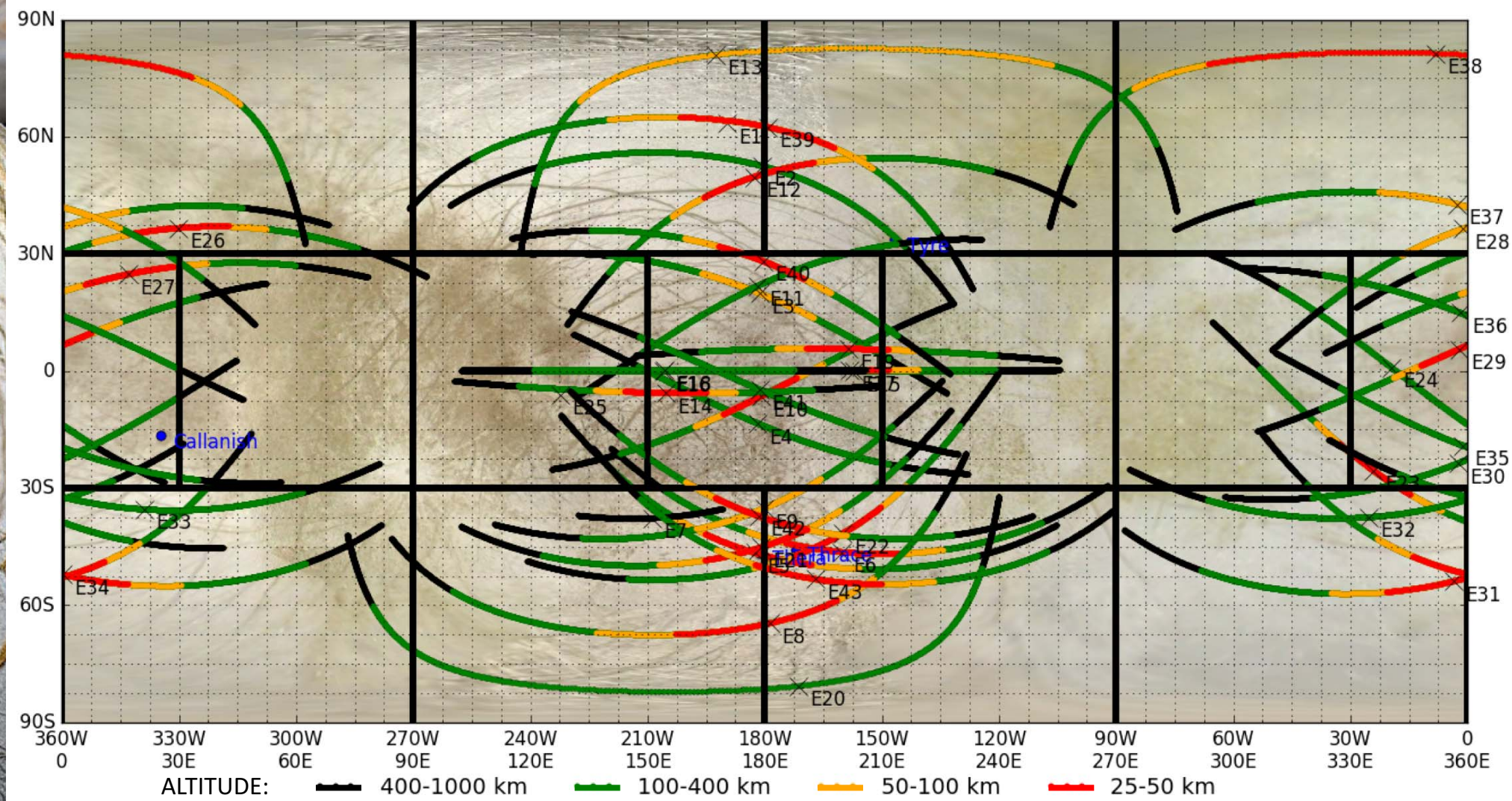
- Minimal spacecraft scanning for distant surveys (>33,000 km)
- Nadir-pointed orientation during flyby period (within ±33,000 km)
- Solar panels parked during closest approach (within ±1000 km)



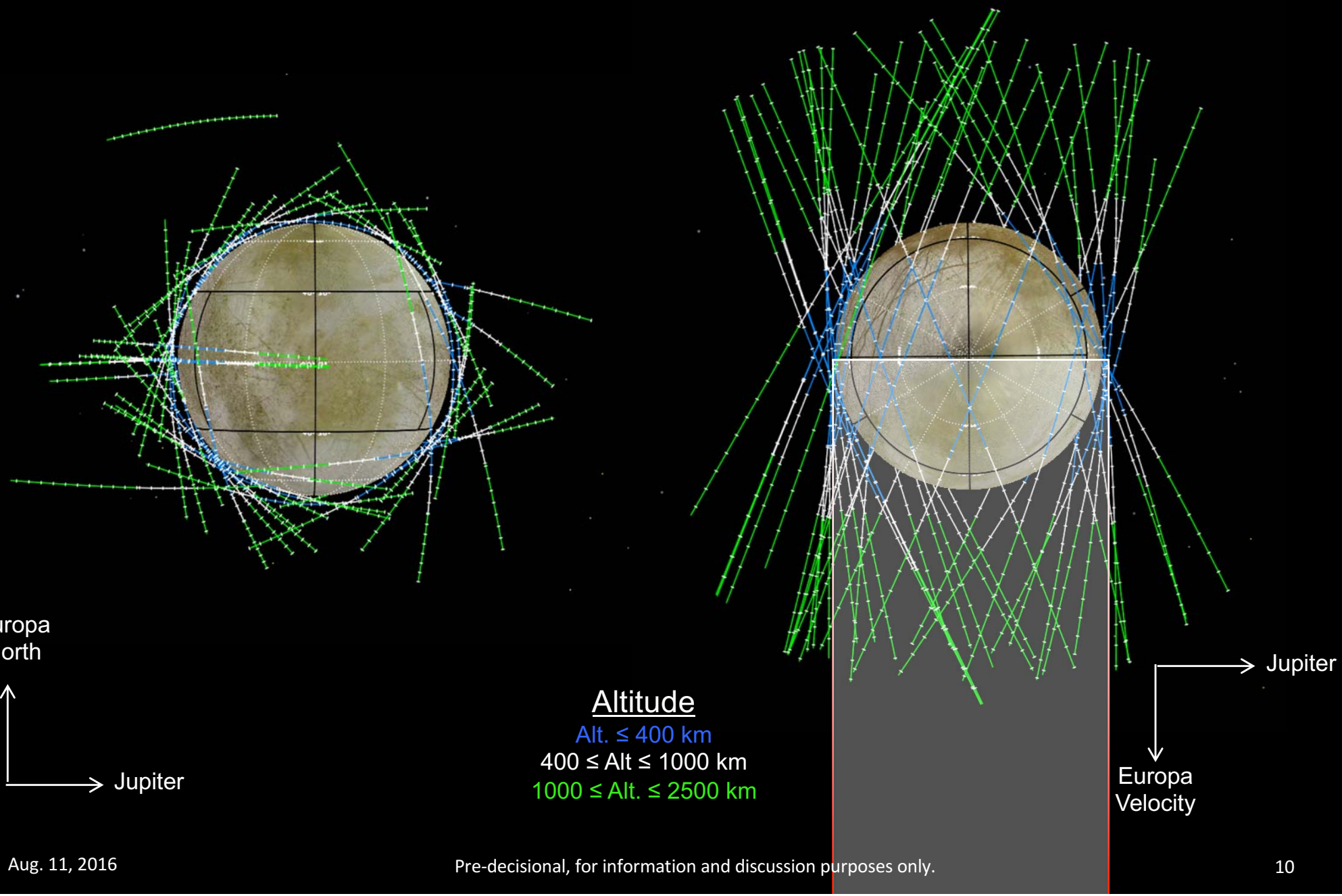
Pre-decisional, for information and discussion purposes only.

4. Trajectory Development (16F10)

- First tour designed to meet requirements of selected payload
- 43 Europa flybys over 3.3 yr



Trajectory Development (16F10)



Pre-decisional, for information and discussion purposes only.

5. Addressing the Ladder of Life: Rough Cut

Ladder Rung	Feature	Clipper	Target
Life (metabolism, growth, reproduction)			
Darwinian Evolution	changes in heritable traits in response to selective pressures	Monolith.	
Growth and Reproduction	concurrent life stages or identifiable reproductive form [growth and reproduction]	EIS?	Squid.
Metabolism	isotopes	MISE?, SUDA?, MASPEX	Plumes, Patches [caveat on sensitivity needed to conclude metabolic effect]
	co-located reductant and oxidant (e.g. persistant H2 +/- CH4 v. O2, nitrate, Fe3+, CO2) [Inferred Persistence]	UVS, MISE, SUDA, MASPEX [split into yellow and green based on plume]	Plumes, Patches, Surface [Green only with Plume!]
Suspicious biomaterials [not necessarily bio			
Functional Molecules	DNA		
	RNA		
	pigments	EIS?	Patches,
	structural preferences in organic molecules [non random and enhancing function)	MASPEX, SUDA, MISE	Plumes, Patches
Potential Biomolecule Components	complex organics (peptides, PAH, nucleic acids, hopanes)	MASPEX, SUDA, MISE	Plumes, Patches
	amino acids (e.g. glycine, alanine)	MISE, SUDA, MASPEX	Patches, Plumes,
	lipids (fatty acids, esters, carboxylic acids)	MASPEX, SUDA, MISE	Plumes, Patches
General indicators	distribution of metals [e.g. vanadium in oil reserves or others like Fe, Ni, Mo/W, Co, S, Se, P]	MISE, UVS, SUDA, MASPEX	Patches, Plumes,
	patterns of complexity (organics)	MISE, SUDA, MASPEX	Patches, Plumes,
	chirality	MISE?	Patches,
Habitability			
	water, presence of building blocks for use, energy source, gradients	MASPEX, SUDA, PIMS, ICEMAG, UVS, EIS, MISE, E-THEMIS, REASON, Gravity,	Plumes desirable, Surface, Patches, Sub-surface

First-order assessment by Europa Science Team, led by Habitability Working Group (Lunine, Hand co-chairs)

Colors refer to ability of Europa payload to address properties or materials cited in "Feature" column:

Blue: Payload provides a comprehensive investigation that fully addresses

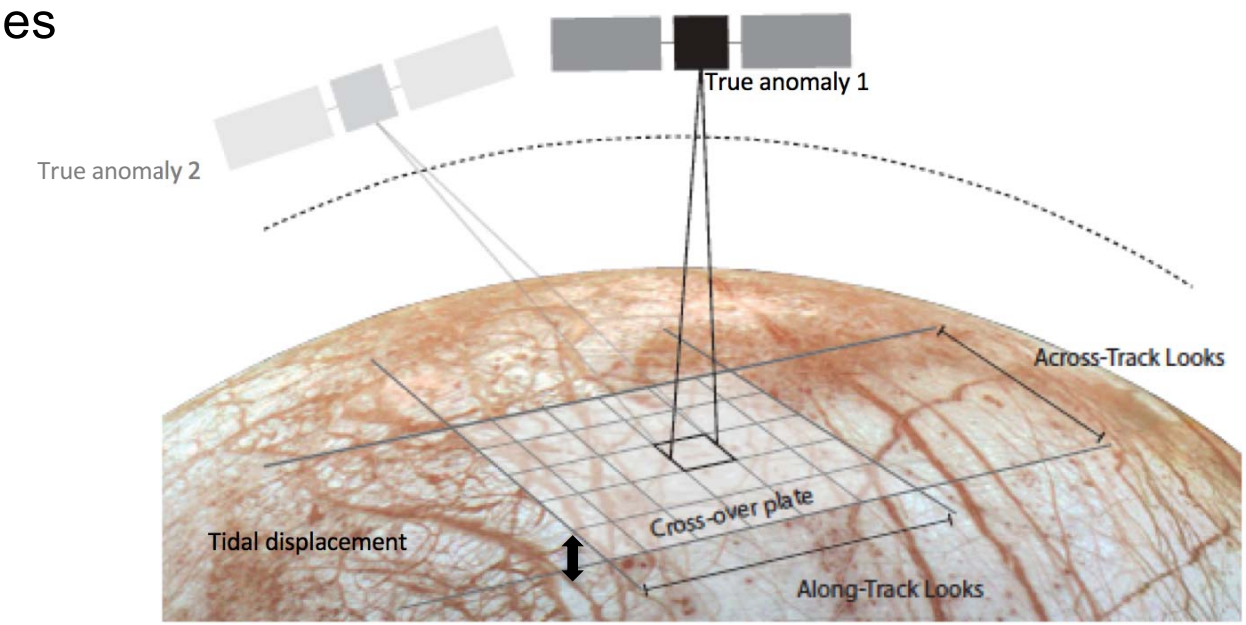
Green: Two or more instruments can address

Yellow: Two or more instruments can probably address (more work required to confirm)

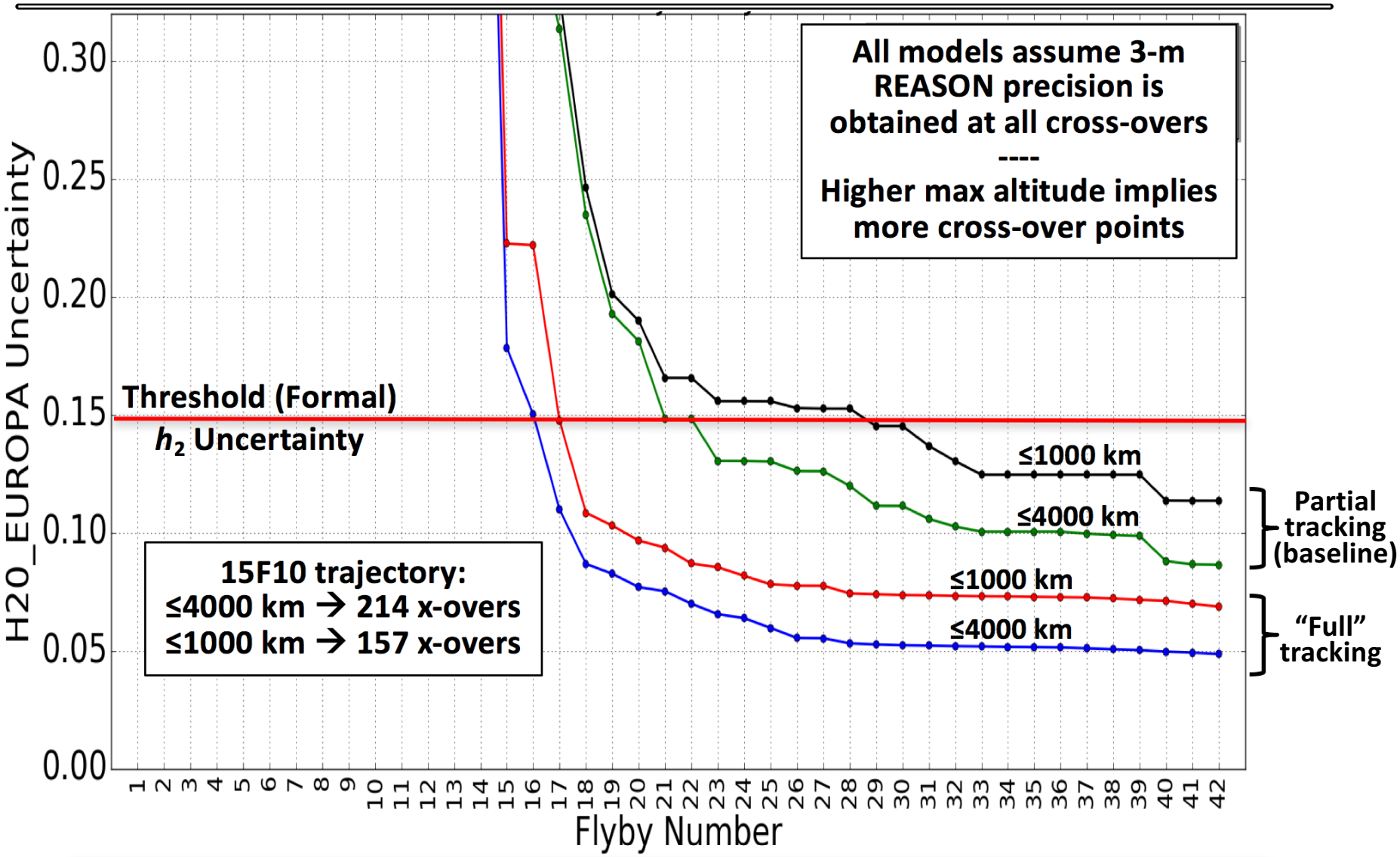
Red: cannot address or only one instrument can possibly address (more work required to confirm)

6. Altimetry for Ocean Detection

- To confirm or refute a Europa ocean via altimetric measurements, the mission should determine the radial displacement Love number $h_2 < 0.3$ actual uncertainty (requiring $h_2 < 0.15$ formal uncertainty)
- REASON radar altimetry + EIS stereo imaging (to determine RMS topography at cross-over points) + near-full gravity tracking can achieve the threshold h_2 uncertainty necessary to confirm an ocean
- Reducing the threshold gain necessary for Doppler tracking and utilizing LGAs to increase tracking coverage, the flybys successfully tracked increase from $\lesssim 13$ to $\gtrsim 31$, including an increase from 1 to ~7 high-latitude passes



Uncertainty in h_2: Effects of Altitude and Tracking



Near-full Doppler tracking permits determination of h_2 from radar altimetry with sufficient uncertainty to confirm or refute an ocean.

7. Europa Science Team News

- Louise Prockter named new Director of the Lunar & Planetary Institute!
- Haje Korth is our new APL Deputy Project Scientist!
- New E-THEMIS (thermal-IR) Co-Is:
  - Paul Hayne (JPL)
  - Mike Mellon (APL)
  - Sylvain Piqueux (JPL)
  - Julie Rathbun (Univ. Redlands / PSI)
  - Carly Howett (SwRI, Boulder)
- Just one Europa PSG meeting planned in FY ‘17
  - May 17–19 or June 27–29, 2017

PSG #4: Monolith Award to Margaret Kivelson

PSG #4: Monolith Award to Margaret Kivelson