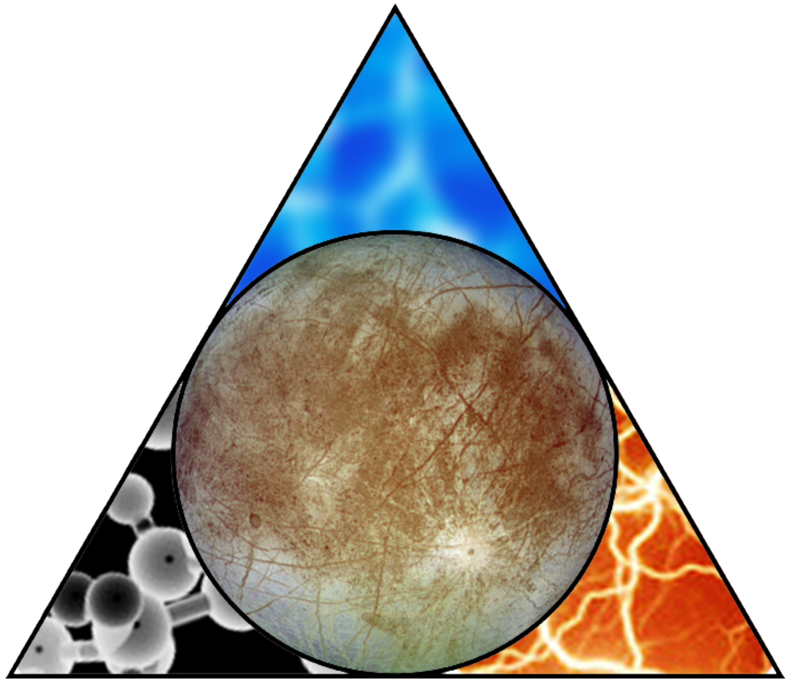
Europa Mission Studies

OPAG March 29, 2012

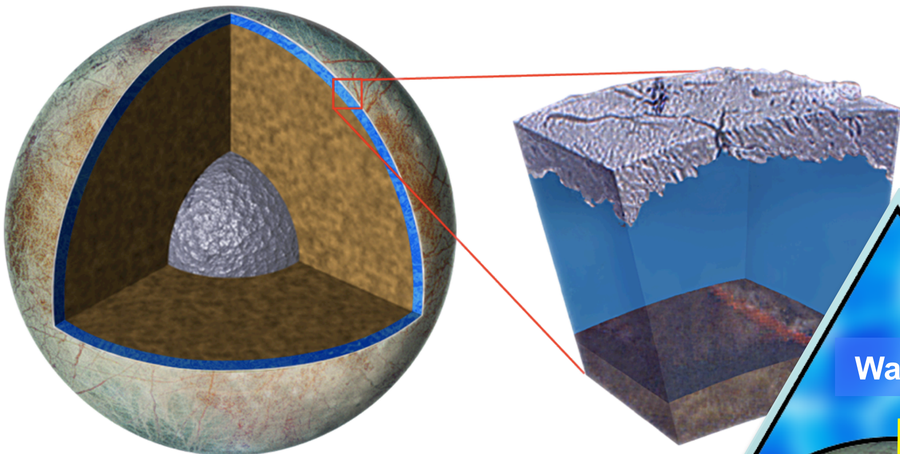


Europa Mission Studies: Introduction

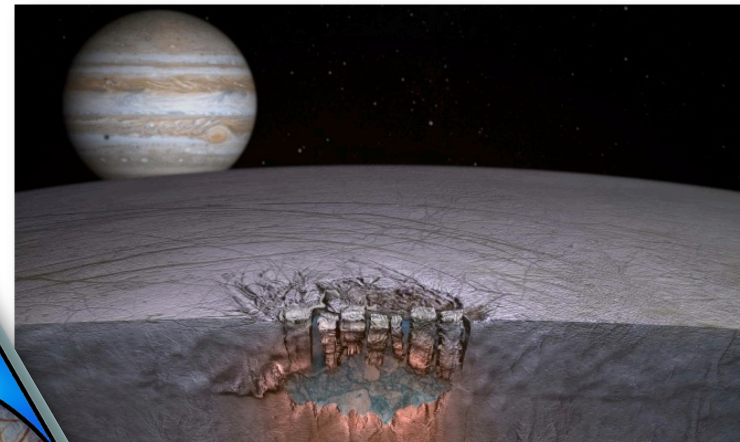
Louise Prockter (APL)
Deputy Europa Study Scientist

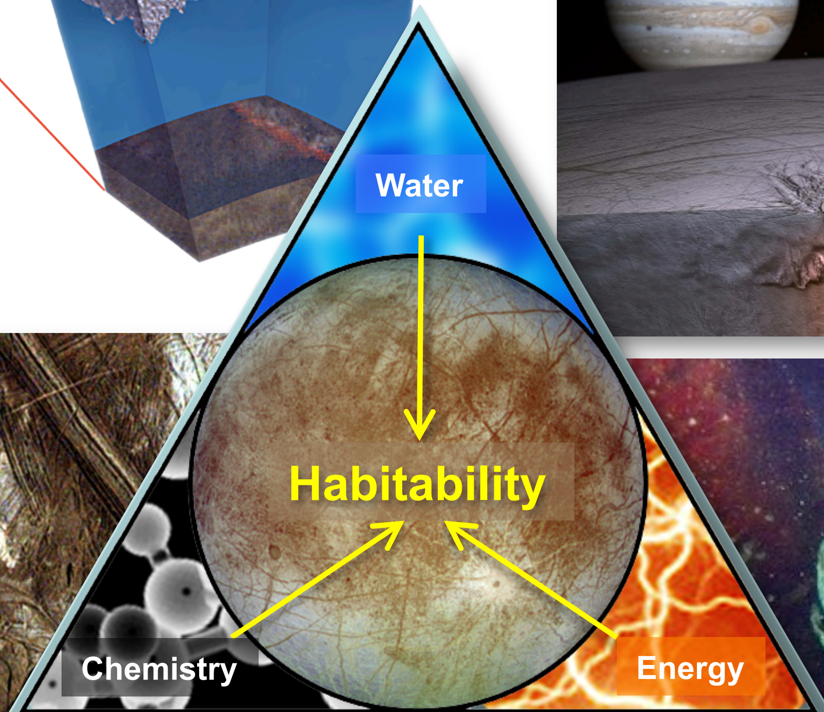
OPAG March 29, 2012

Europa: Ingredients for Life?



Water: Does Europa have a global ocean and lakes hidden within the ice?





Chemistry: Do red surface deposits contain salts and organics from below?

Energy: Can chemical disequilibrium provide energy for metabolism?

Europa Science Definition Team
2011-2012

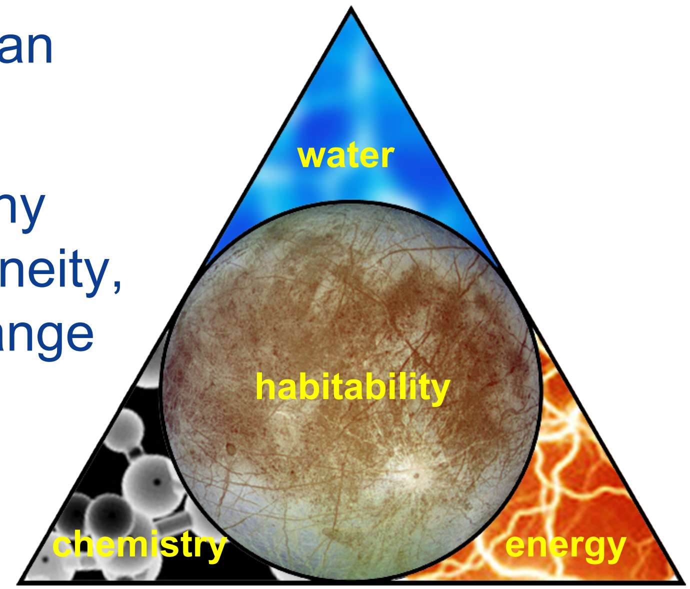
Fran Bagenal	Univ. Colorado	Space Physics
Amy Barr	Brown Univ.	Geophysics
Bruce Bills	JPL	Geophysics
Diana Blaney	JPL	Composition
Don Blankenship	Univ. Texas	Ice shell
Will Brinckerhoff*	GSFC	Astrobiology
Jack Connerney	GSFC	Magnetometry
Kevin Hand*	JPL	Astrobiology
Tori Hoehler*	Ames	Astrobiology
Bill Kurth	Univ. Iowa	Plasma
Melissa McGrath	MSFC	Atmosphere
Mike Mellon*	SWRI	Ice Physics / Geology
Jeff Moore	Ames	Geology
Bob Pappalardo	JPL	Chair / Study Scientist
Louise Prockter	APL	Deputy / Geology
Dave Senske	JPL	Deputy / Geology
Everett Shock*	ASU	Geochemistry
David Smith	MIT	Geophysics

*SDT augmentations for lander study

Science Goal, Objectives, and Themes

- *Goal:* Explore Europa to investigate its habitability
- *Objectives:*
  - *Ocean:* Characterize the extent of the ocean and its relation to the deeper interior
  - *Ice Shell:* Characterize the ice shell and any subsurface water, including their heterogeneity, 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….

Themes:



Science as a Driver of Mission Architecture

Science traceability led to mission concepts:

Orbiter Element: ***Geophysical measurements that can be achieved only from orbit***

- Science focused primarily to address "Ocean" objective:
  - Gravity field
  - Tidal amplitude
  - Induction signatures
  - Plasma correction
  - Stratigraphic mapping

Flyby Element: ***Remote measurements that can be accomplished via multiple flybys***

- Science focused primarily to address "Chemistry" and "Energy" themes:
  - Subsurface dielectric horizons
  - Surface constituents
  - Atmospheric constituents
  - Targeted landforms

- Each element achieves key Europa science objectives
- The elements are complementary, and each has very high science value of its own

Orbiter and Flyby Mission Options

Objective	Europa Science	Orbiter	Multiple Flyby
Ocean	Gravity field	✓	
	Tidal amplitude	✓	
	Induction signatures	✓	
	Plasma correction	✓	
Ice Shell	Subsurface dielectric horizons		✓
Composition	Surface constituents		✓
	Atm. constituents		✓
Geology	Global mapping	✓	
	Targeted landforms		✓

Orbiter Mission Traceability

Ocean Emphasis

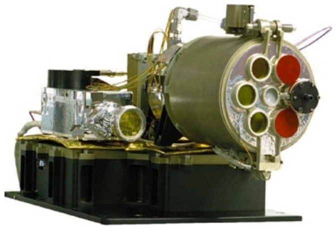
Goal	Objective		Investigation		Model Instruments	Theme W	Theme C	Theme E
Explore Europa to investigate its habitability	Ocean	Characterize the extent of the ocean and its relation to the deeper interior.	O.1	Determine the amplitude and phase of gravitational tides.	Radio subsystem, Laser altimeter	✓		
			O.2	Determine Europa's magnetic induction response.	Magnetometer, Langmuir probe	✓	✓	
			O.3	Determine the amplitude and phase of topographic tides.	Laser altimeter, Radio subsystem	✓		
			O.4	Determine Europa's rotation state.	Laser altimeter, Mapping camera	✓		
			O.5	Investigate the deeper interior.	Radio subsystem, Laser altimeter, Magnetometer, Langmuir probe	✓	✓	✓
	Geology	Understand the formation of surface features, including sites of recent or current activity to understand regional and global evolution.	G.1	Determine the distribution, formation, and three-dimensional characteristics of magmatic, tectonic, and impact landforms.	Mapping camera, Laser altimeter	✓		✓

Themes: W= Water, C = Chemistry, E = Energy

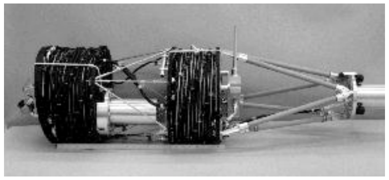
Orbiter Model Payload Instruments

- Radio Subsystem (RS)
  - X-band up and down; Ka-band down only
  - Ka Transponder
- Laser Altimeter (LA)
  - Nadir view, co-boresighted with camera on 2-axis gimbal platform
- Magnetometer (MAG)
  - Dual 3-axis fluxgate
  - Sensors on boom 5 m and 10 m from S/C
- Langmuir Probe (LP)
  - Two 5 cm diameter spheres mounted on 1 m long booms pointed > 90° from each other
- Mapping Camera (MC)
  - Pushbroom imager; 1024 pixel CMOS or CCD line array
  - 5 separate line arrays in focal plane (radiation shielded)
    - 4 nadir viewing: panchromatic + 3 color bands (color for E/PO)
    - 1 panchromatic viewing ~40° forward or aft for stereo
  - Nadir view, co-boresighted with LA on 2-axis gimbal platform

Similar instruments



NEAR NLR



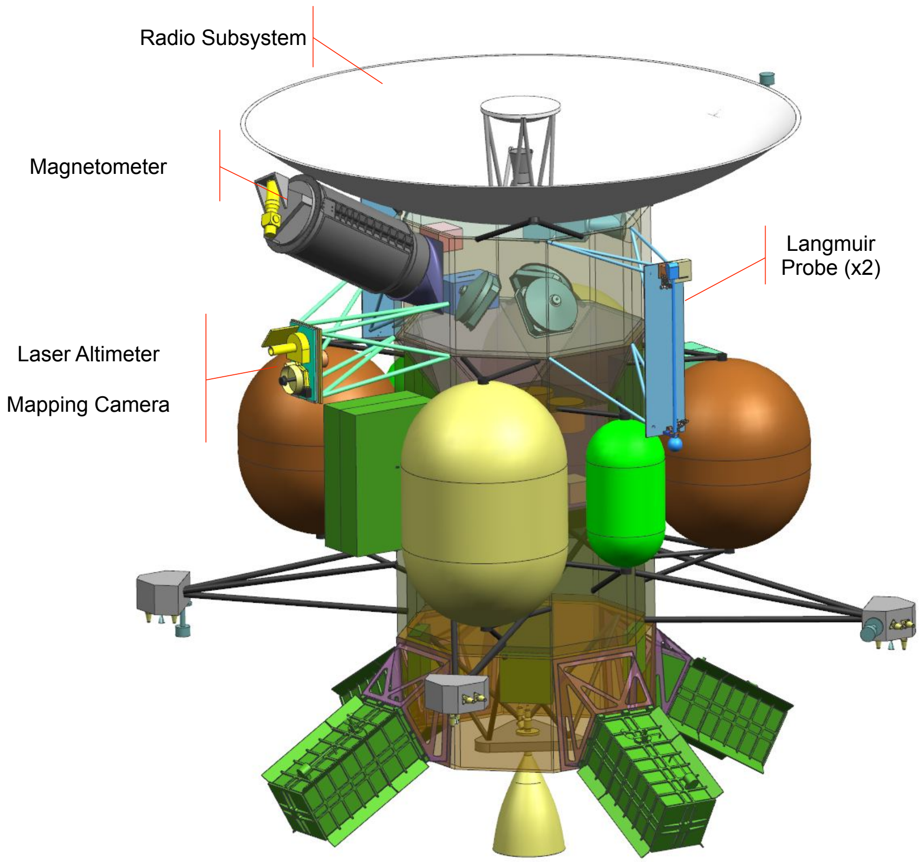
Galileo MAG

Rosetta LAP

MPL/MSL MARDI

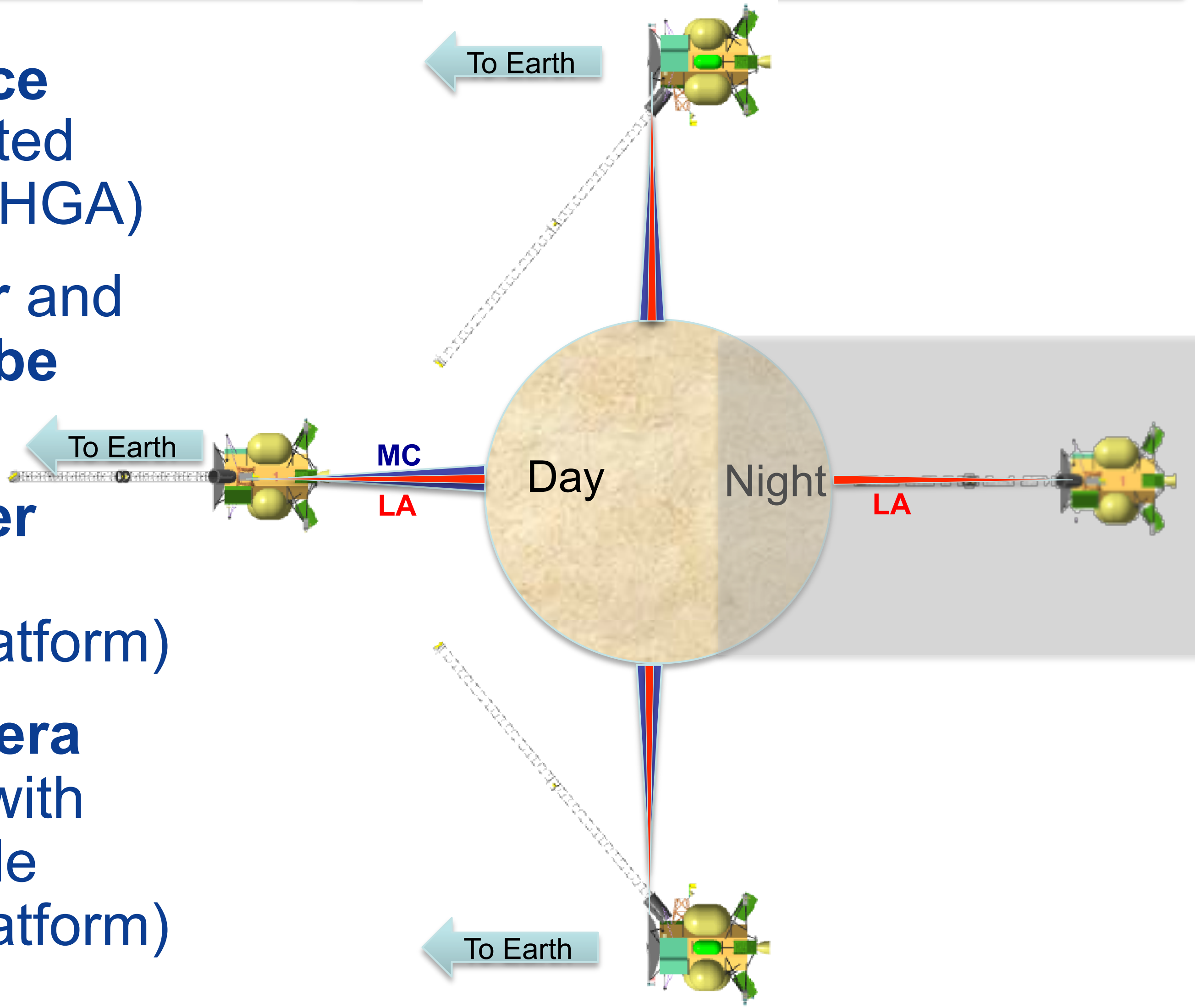
Orbiter Mission Configuration

- 3-axis stabilized, functionally redundant spacecraft
- 5 reference science instruments
- 4 ASRGs, 59 Ahr Battery
- X/Ka-band, 3 m fixed HGA, 129 kbit/sec average downlink
- Dual mode, Bi-prop 890 N main engine, 16 RCS thrusters. Capable of 2.3 km/s Delta-V



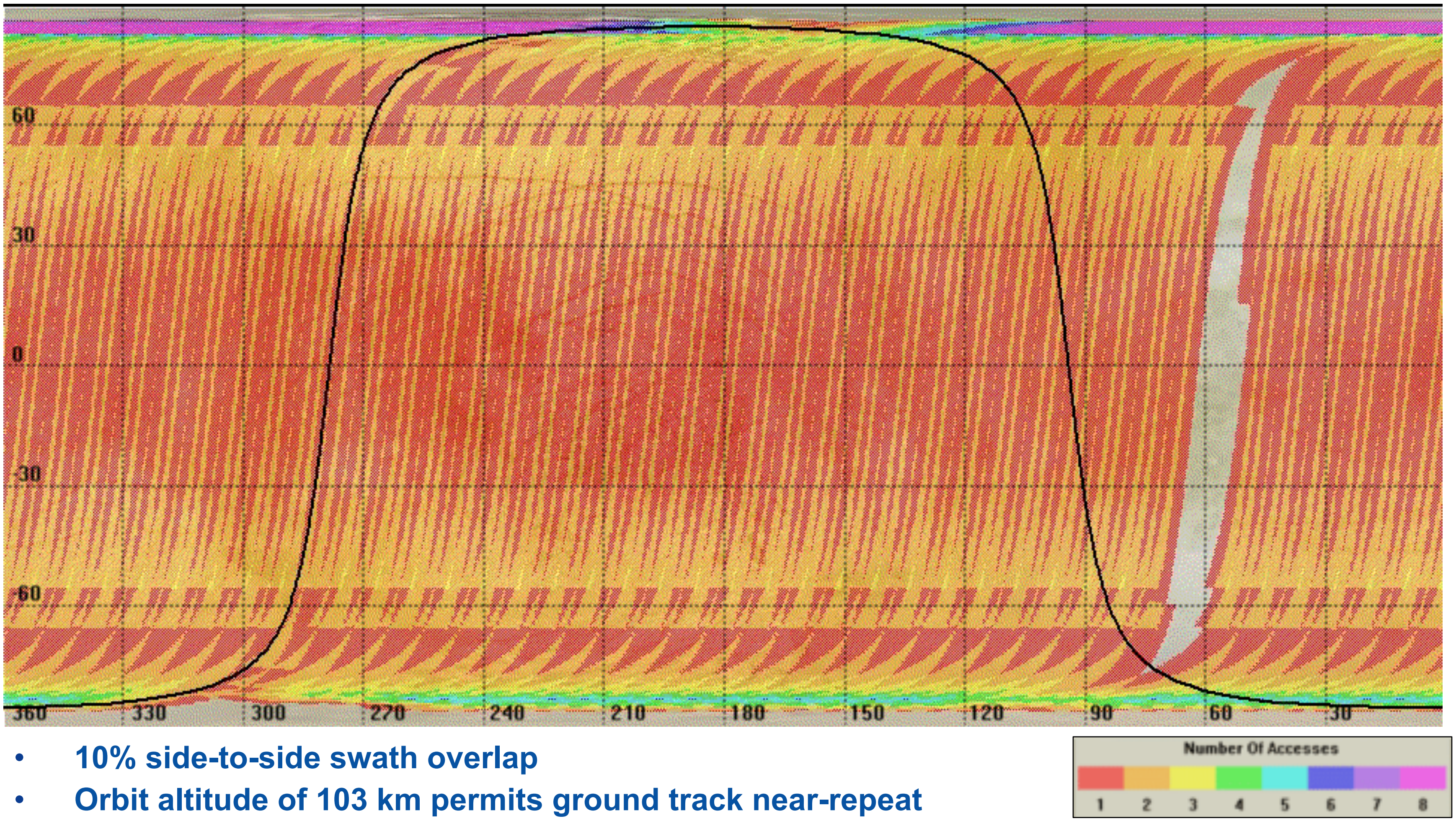
Orbiter Science Operations Concept

- **Gravity Science** while not occulted (Earth-pointed HGA)
- **Magnetometer** and **Langmuir Probe** on all the time
- **Laser Altimeter** on all the time (2 axis scan platform)
- **Mapping Camera** on during day with ~45% duty cycle (2 axis scan platform)



Mapping Camera

Global Stereo Map in 3 Eurosols (<11 days)



- **10% side-to-side swath overlap**
- **Orbit altitude of 103 km permits ground track near-repeat**
- **1024-pixel line width ~100 m/pixel average resolution across FOV**
- **Wide gap is due to Jupiter occultation; It could be filled through off-nadir pointing**

Pre-Decisional — For Planning and Discussion Purposes Only

Flyby Mission Traceability

Chemistry & Energy Emphasis

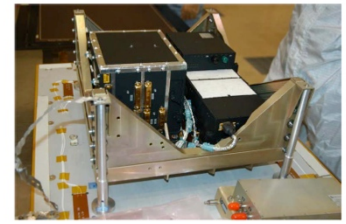
Goal		Objective		Investigation	Model Instr.	Theme W	Theme C	Theme E
Explore Europa to investigate its habitability	Ice Shell	Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange.	I.1	Characterize the distribution of any shallow sub-surface water and the structure of the icy shell.	Radar sounder, Topo. Imager	✓		✓
			I.2	Search for an ice-ocean interface.	Radar sounder, Topo. Imager	✓		✓
			I.3	Correlate surface features and subsurface structure to investigate processes governing material exchange among the surface, ice shell, and ocean.	Radar sounder, IR spectrometer, Topo. imager	✓	✓	✓
			I.4	Characterize regional and global heat flow variations.	Radar sounder	✓		✓
	Composition	Understand the habitability of Europa's ocean through composition and chemistry.	C.1	Characterize the composition and chemistry of the Europa ocean as expressed on the surface and in the atmosphere.	IR spectrometer, INMS	✓	✓	
			C.2	Determine the role of Jupiter's radiation environment in processing materials on Europa.	IR spectrometer, INMS		✓	✓
			C.3	Characterize the chemical and compositional pathway's in Europa's ocean.	IR spectrometer, INMS	✓	✓	
	Geology	Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.	G.2	Determine sites of most recent geological activity, and characterize high science interest localities.	Topo. Imager	✓		✓

Themes: W= Water, C = Chemistry, E = Energy

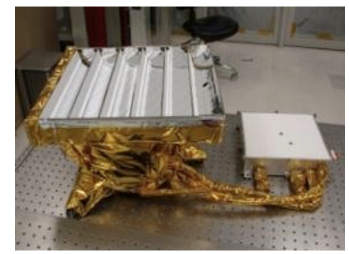
Flyby Model Payload Instruments

- Ice Penetrating Radar (IPR)
  - Dual-frequency sounder
    - 60 MHz with 10 MHz bandwidth (shallow)
    - 9 MHz with 1 MHz bandwidth (deep)
  - Deployed dipole antenna array on 15 m boom
- ShortWave InfraRed Spectrometer (SWIRS)
  - Spectral Range 0.85 – 5.0 µm; Spectral Resolution 10 nm
  - Single optic, single grating spectrometer & HgCdTe detector
  - Scan mirror for Target Motion Compensation
- Topographical Imager (TI)
  - Pushbroom, 4096 pixels width
  - Stereo obtained through along-track overlap
- Ion and Neutral Mass Spectrometer (INMS)
  - Mass Range 1 – 300 Da; Mass Resolution > 500; Sensitivity 10 particles/cm^3

Similar instruments

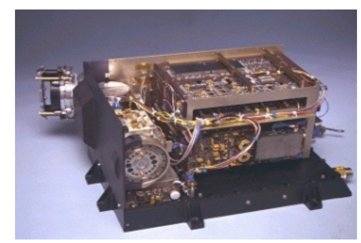


MRO SHARAD



LRO M^3

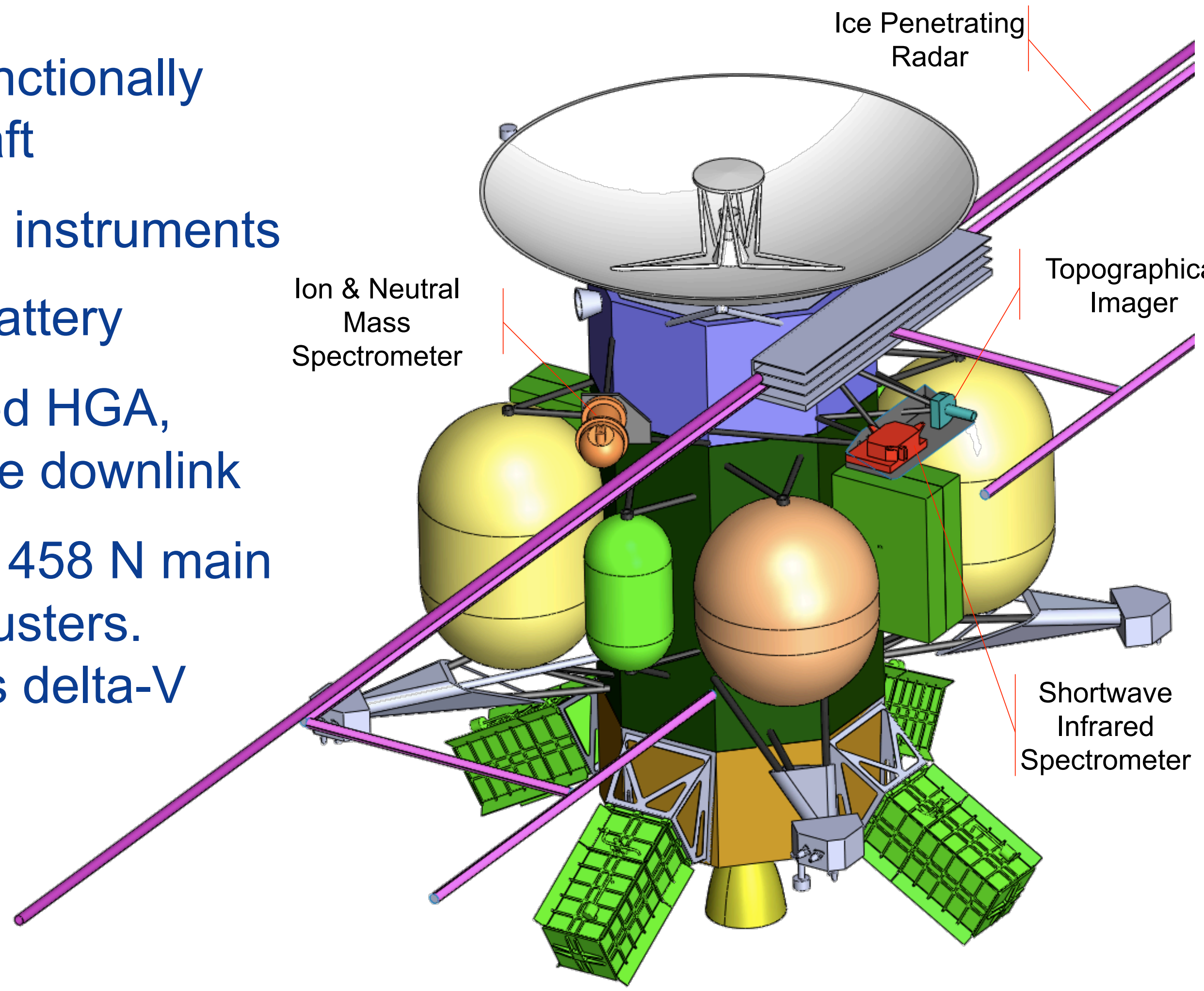
New Horizons Ralph/MVIC



Cassini INMS

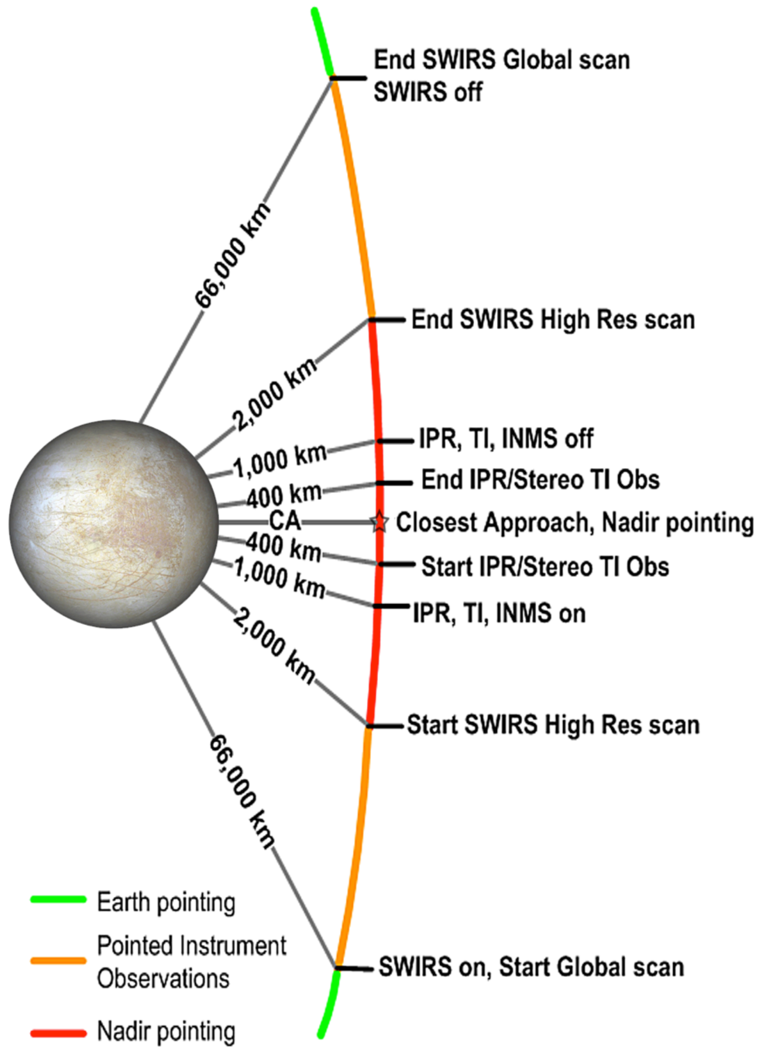
Flyby Mission Configuration Overview

- 3-axis stabilized, functionally redundant spacecraft
- 4 reference science instruments
- 4 ASRGs, 59 Ahr Battery
- X/Ka-band, 3 m fixed HGA, 134 kbit/sec average downlink
- Dual mode, Bi-prop 458 N main engine, 16 RCS thrusters. Capable of 1.6 km/s delta-V

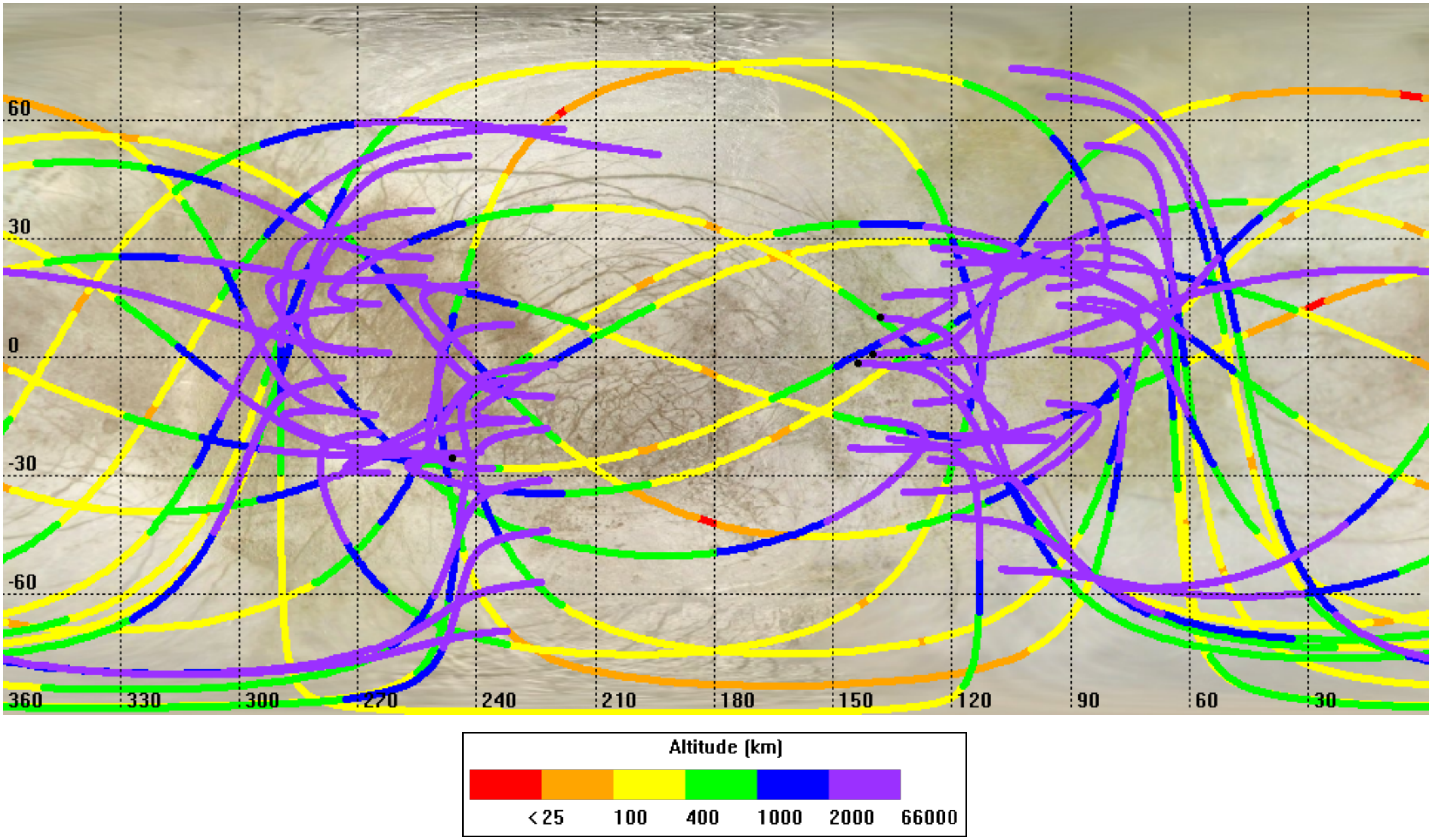


Flyby Science Operations Concept

- **Ice Penetrating Radar** obtains primary data at ≤ 400 km
- **ShortWave InfraRed Spectrometer** obtains data ≤ 66,000 km
- **Topographical Imager** obtains stereo images ≤ 1,000 km
- **INMS** obtains data ≤ 1,000 km, including several ~25 km flybys



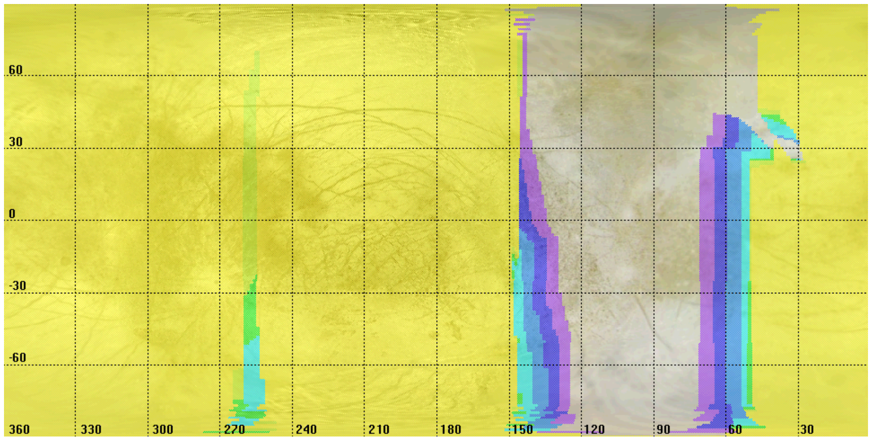
Flyby Ground Tracks



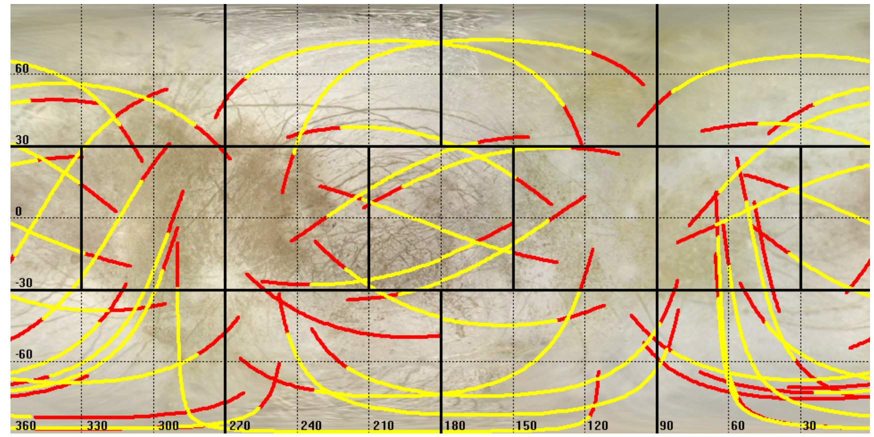
Pre-Decisional — For Planning and Discussion Purposes Only

Instrument Coverage

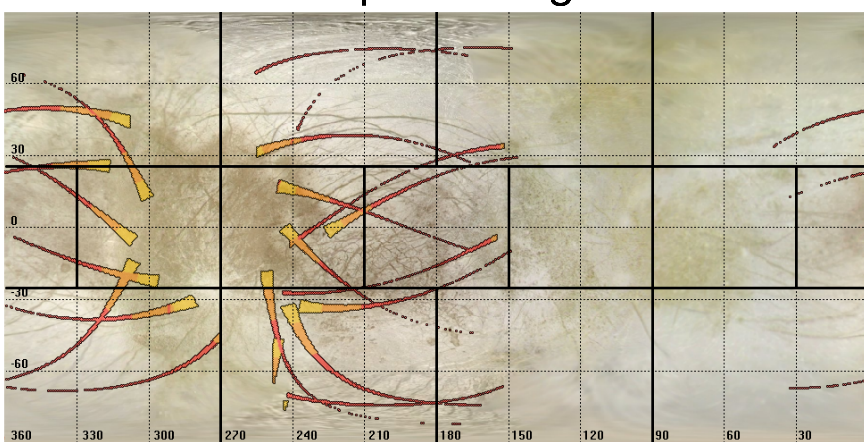
S/W IR Spec. - Low Res



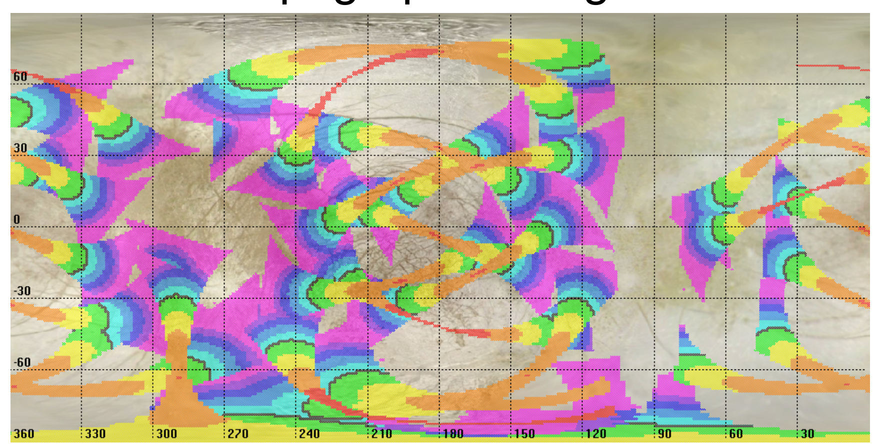
Ice Penetrating Radar



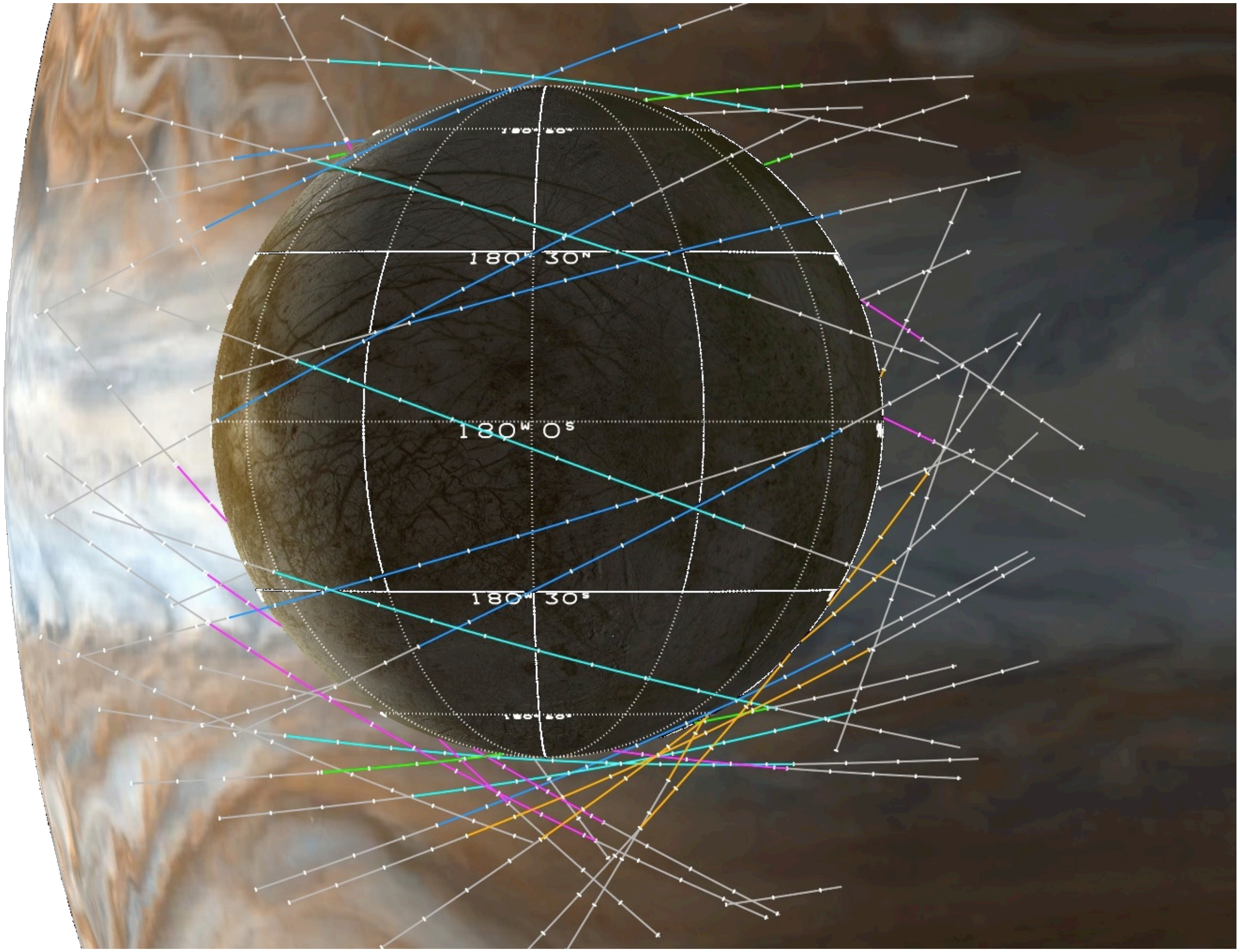
S/W IR Spec. – High Res



Topographic Imager



Flyby Ground Tracks



Pre-Decisional — For Planning and Discussion Purposes Only

Key Science Drivers & Requirements

Instrument(s)	Key Accommodation Requirements	Element
Radio Subsystem + Laser Altimeter	Low altitude (~100+ km), circular, near-polar orbit, for at least 30 days. Unperturbed orbital arcs (no thrusting) of at least 3 days.	Orbiter
Magnetometer + Langmuir Probe	Low altitude (~100+ km), circular, near-polar orbit, for at least 30 days. Cover approximately 12 hours of Europa local time.	Orbiter
Mapping Camera	Low altitude (~100+ km), ≥ 80% global coverage under near uniform lighting conditions, solar incidence angle > 45° (70° preferred).	Orbiter
Ice Penetrating Radar	≥ 800 km tracks in 11 of 14 globally distributed regions, intersected by at least 1 other track, with track lengths measured from ≤ 400 km alt. ~25–100 km closest approach at ≤ 6 km/s.	Flyby
ShortWave IR Spectrometer	≥ 70% coverage at ≤ 10 km per pixel. Ability to target specific geologic locations with a wide range of surface locations, lighting between 9:00am and 3:00pm. Attitude stability < ½ IFOV over integration time, flyby speed < 6 km/s.	Flyby
Topographical Imager	High resolution stereo imagery aligned with IPR coverage; lighting conditions solar incidence angle > 45° (70° preferred).	Flyby
Ion and Neutral Mass Spectrometer	Low altitude (< 200 km with lower altitudes desired) at ≤ 7 km/s; long integration times and low altitudes (≤ 100 km) preferred.	Flyby

Floor model instrument (dark grey) — Baseline model instrument (light grey)

Science as a Driver of Mission Architecture

Science traceability leads to a two element mission concept:

***Orbiter Element:* Geophysical measurements that can be achieved only from orbit**

- Payload focused primarily to address "Ocean" objective:
  - Radio Subsystem (RS)
  - Laser Altimeter (LA)
  - Magnetometer (MAG)
  - Langmuir Probe (LP)
  - Mapping Camera (MC)
- Have readily accommodated those instruments that are:
  - Less massive
  - Lower power
  - Lower data rate

***Flyby Element:* Remote measurements that can be accomplished via multiple flybys**

- Payload focused primarily to address "Chemistry" and "Energy" themes:
  - Ice Penetrating Radar (IPR)
  - ShortWave IR Spectrometer (SWIRS)
  - Ion and Neutral Mass Spectrometer (INMS)
  - Topographical Imager (TI)
- Have readily accommodated those instruments that are:
  - More massive
  - Higher power
  - Higher data rate

A Pragmatic Path to Europa Exploration

- Either an orbiter or multiple-flyby mission option would fulfill high-priority Europa science objectives
  - Orbiter element concentrates on the “Ocean” science
  - Multiple-flyby element concentrates on the “Chemistry” and “Energy” science
- Each element has very high science value on its own
- Directly responsive to Decadal Survey’s recommendation for Europa
- Scientific priorities drive the architecture, permitting low-cost Europa mission options