Current Status of the EJSM Jupiter Europa Orbiter Flagship Mission Design

Presentation to the International workshop:

"Europa lander: science goals and experiments"

2/09

Presented by:

Karla B. Clark

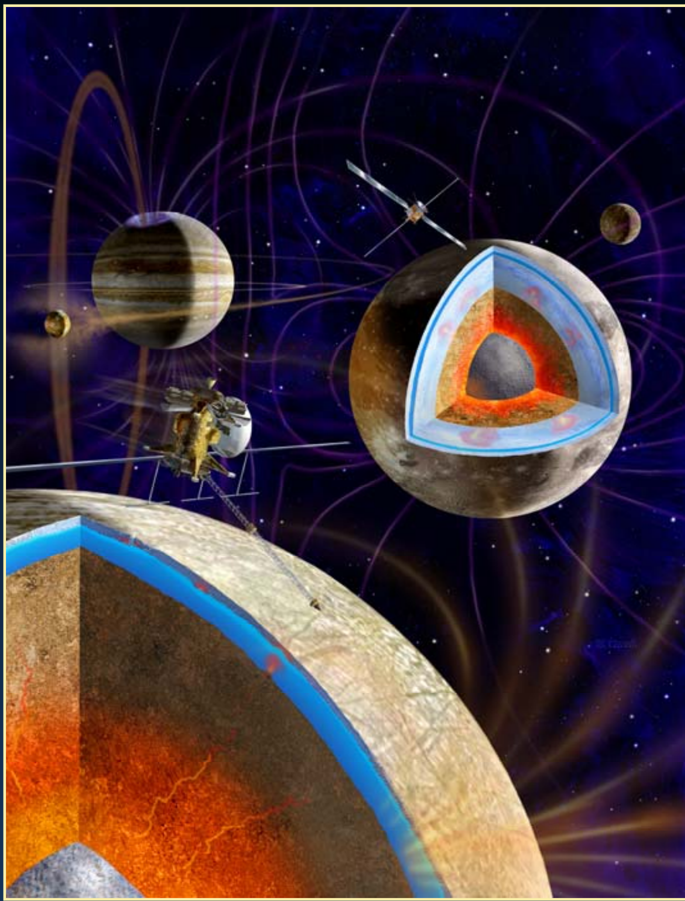
EJSM–JEO Study Manager

Jet Propulsion Laboratory

California Institute of Technology

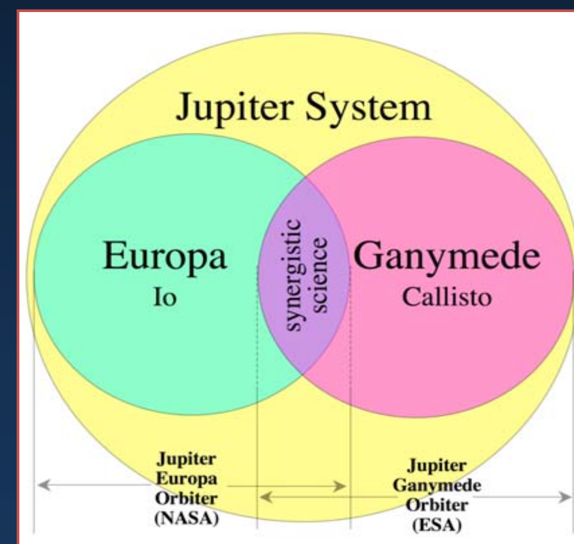
Jupiter Europa Orbiter

The NASA Element of the Europa Jupiter System Mission



EJSM Baseline Mission Overview

- NASA & ESA share mission leadership
- Two independently launched and operated flight systems with complementary payloads
  - Jupiter Europa Orbiter (JEO): NASA-led mission element
  - Jupiter Ganymede Orbiter (JGO): ESA-led mission element
- Mission Timeline
  - Nominal Launch: 2020
  - Jovian system tour phase: 2–3 years
  - Moon orbital phase: 6–12 months
  - End of Prime Missions: 2029
- ~10–11 Instruments on each flight system, including Radio Science



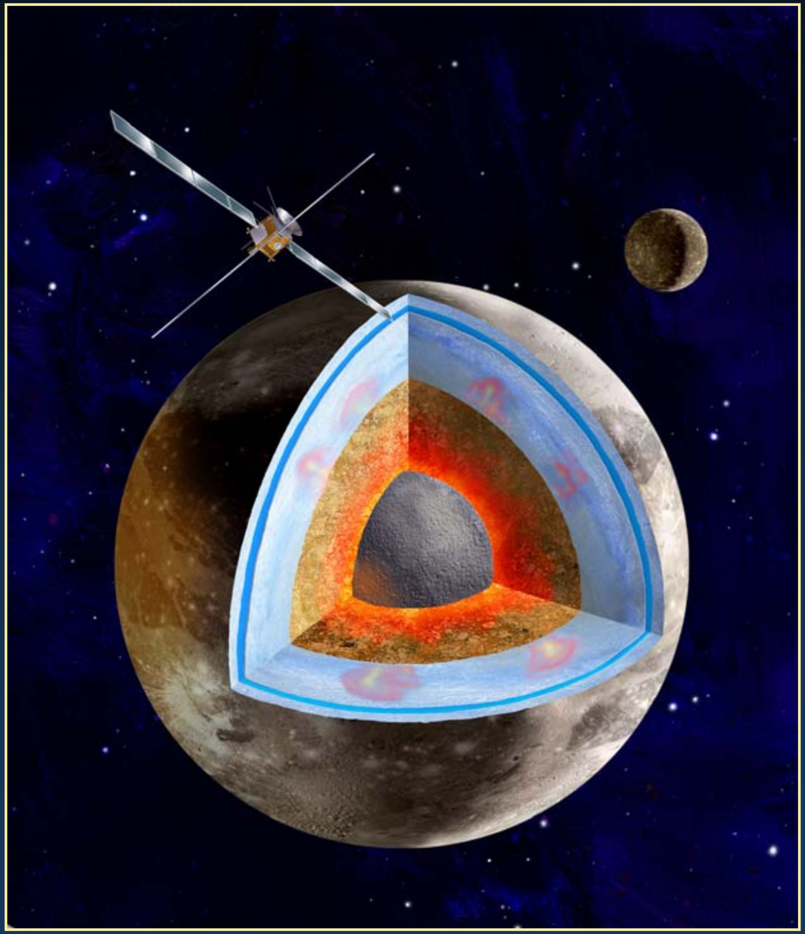
JGO Baseline Mission Overview

- ESA-led portion of EJSM
- Objectives: Jupiter System, Callisto, Ganymede
- Launch vehicle: Arianne 5
- Power source: Solar Arrays
- Mission timeline:
  - Launch: 2020
    - Uses 6-year Venus-Earth-Earth gravity assist trajectory
  - Jovian system tour phase: ~28 months
    - Multiple satellite flybys
      - 9 Ganymede
      - 21 Callisto (19 close flybys)
  - Ganymede orbital phase: 260 days
  - End of prime mission: 2029
  - Spacecraft final disposition: Ganymede surface impact
- **Radiation**: ~85 krad behind 320 mils of Al (requirement to keep it below 100 krad)

Wide Angle and Medium Resolution Camera
V/NIR Imaging Spectrometer
EUV/FUV Imaging Spectrometer
Ka-band transponder
Ultra Stable Oscillator
Magnetometer
Radar Sounder
Micro Laser Altimeter
Thermal IR Mapper
Sub-millimeter wave sounder
Plasma Package

JGO Science

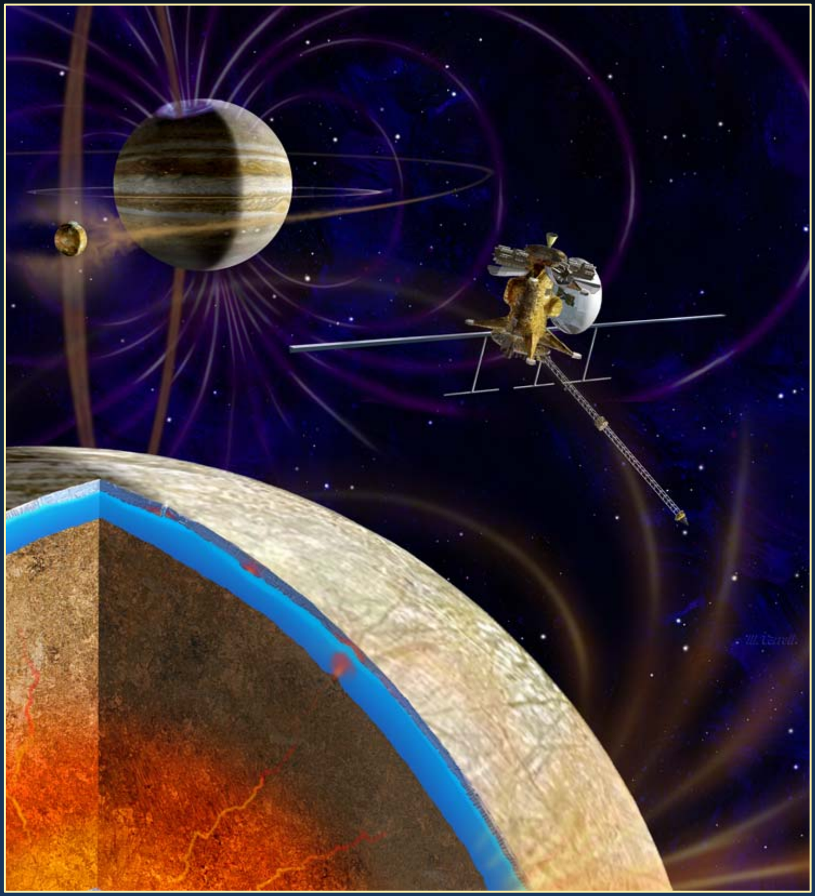
- Key Science Objectives
  - In depth post-Galileo exploration of the **Jupiter system**, synergistically with JEO
    - En route to Callisto and Ganymede
  - In-depth study and full mapping of **Callisto**
    - Multiple flybys using a resonant orbit
  - Detailed orbital study of **Ganymede**
    - Two successive dedicated moon orbits (elliptical first, then circular)
- A major step forward in our understanding of the two “icy” Galilean satellites, Ganymede and Callisto:
  - Ocean detection/characterisation
  - State of internal differentiation
  - Global surface mapping: morphology and chemistry
  - Comprehensive study of Ganymede’s magnetism
  - Relations between thermal history, geology, oceans and the Laplace resonance



JEO Baseline Mission Overview

- NASA-led portion of EJSM extensively studied in 2007–2008
- Objectives: Jupiter System, Europa
- Launch vehicle: Atlas V 551
- Power source: 5 MMRTG or 5 ASRG
- Mission timeline:
  - Launch: 2018 to 2022, nominally 2020
    - Uses 6-year Venus-Earth-Earth gravity assist trajectory
  - Jovian system tour phase: 30 months
    - Multiple satellite flybys: 4 Io, 6 Ganymede, 6 Europa, and 9 Callisto
  - Europa orbital phase: 9 months
  - End of prime mission: 2029
  - Spacecraft final disposition: Europa surface impact
- 11 Instruments, including radio science
- Radiation dose: 2.9 Mrad (behind 100 mils of Al)
  - Handled using a combination of rad-hard parts and tailored component shielding
  - Key rad-hard parts are available, with the required heritage
  - Team is developing and providing design information and approved parts list for prospective suppliers of components, including instruments

JEO Goal: Explore Europa to Investigate Its Habitability



Objectives:

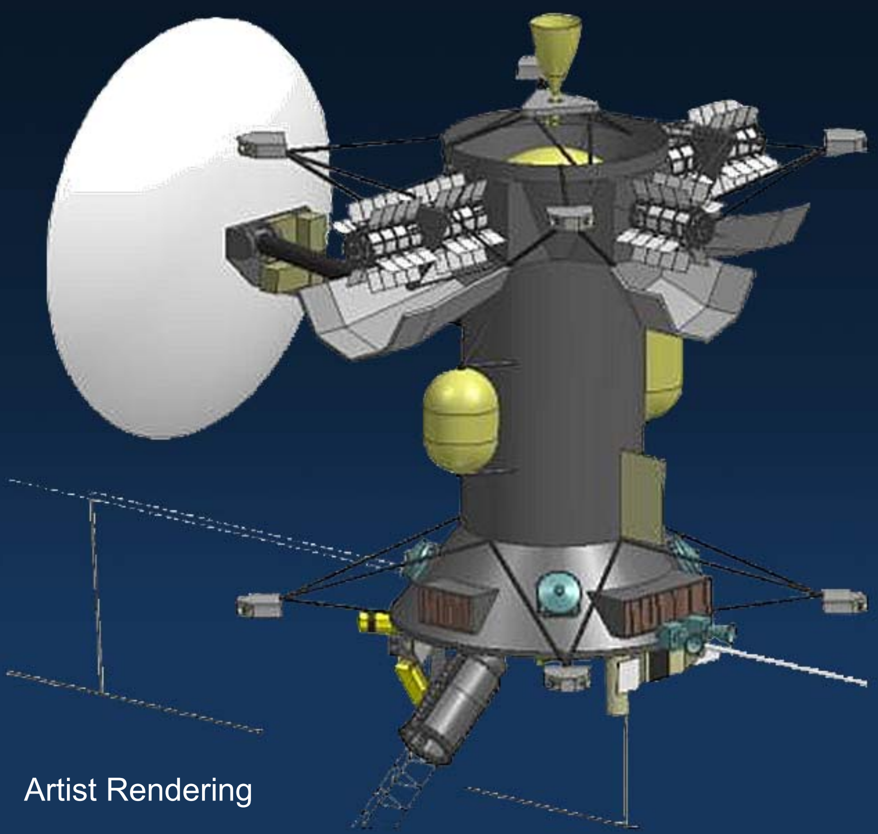
- Ocean and Interior
- Ice Shell
- Chemistry and Composition
- Geology
- Jupiter System
  - Satellite surfaces and interiors
  - Satellite atmospheres
  - Plasma and magnetospheres
  - Jupiter atmosphere
  - Rings

Europa is the archetype of icy world habitability

JEO Model Payload

JEO Instrument	Similar Instruments
Radio Science	New Horizons USO, Cassini KaT
Laser Altimeter	MESSENGER MLA, NEAR NLR
Ice Penetrating Radar	MRO SHARAD, Mars Express MARSIS
VIS-IR Spectrometer	MRO CRISM, Chandrayaan MMM
UV Spectrometer	Cassini UVIS, New Horizons Alice
Ion & Neutral Mass Spectrometer	Rosetta ROSINA RTOF
Thermal Instrument	MRO MCS, LRO Diviner
Narrow-Angle Camera	New Horizons LORRI, LRO LROC
Camera Package	MRO MARCI, MESSENGER MDIS
Magnetometer	MESSENGER MAG, Galileo MAG
Particle and Plasma Instrument	New Horizons PEPSSI, Deep Space 1 PEPE

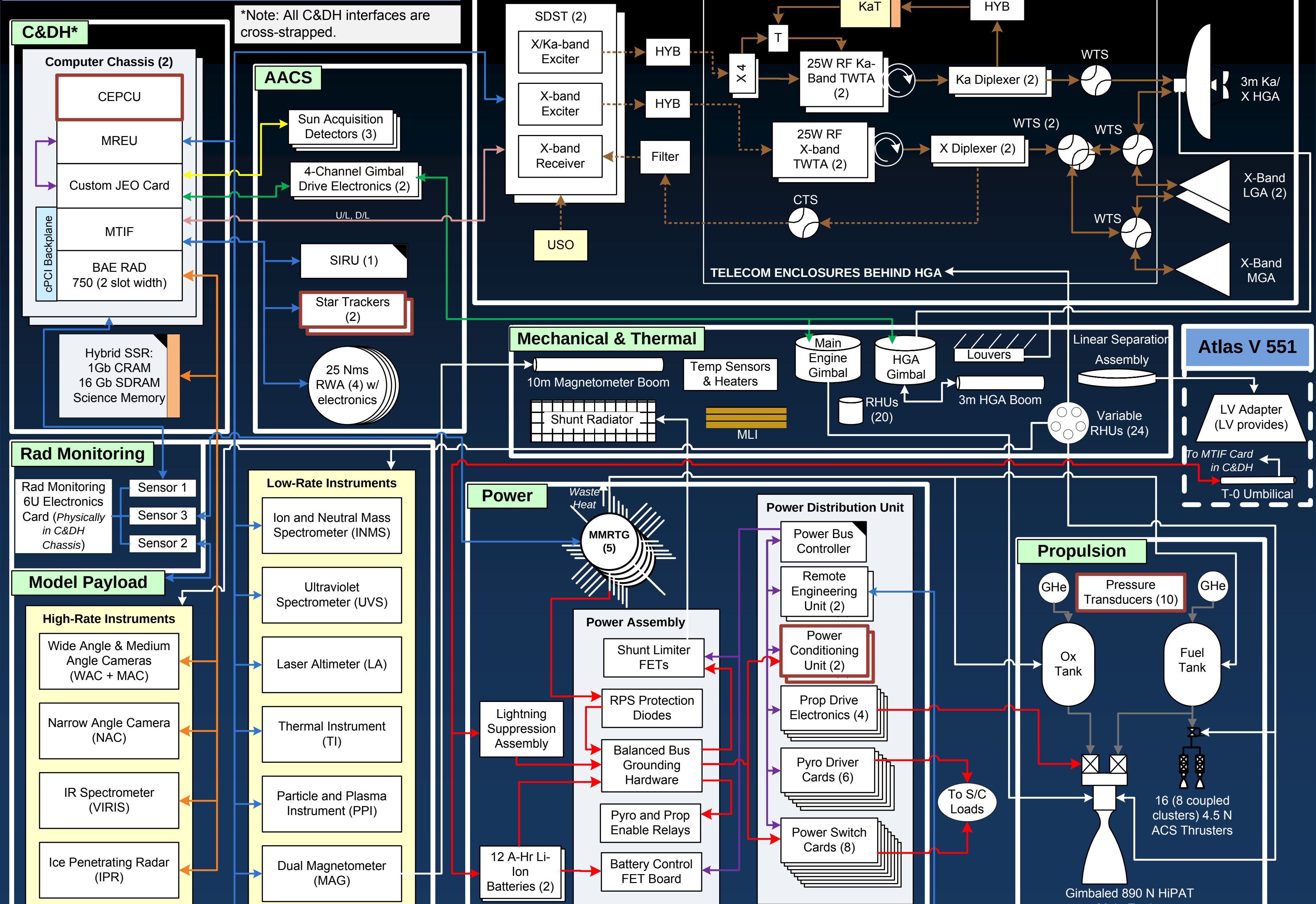
JEO Baseline Flight System


Artist Rendering

- Three-axis stabilized with instrument deck for nadir pointing
- Articulated HGA for simultaneous downlink during science observations
- Data rate of 150 kbps to DSN 34m antenna on Ka-band
- Performs 2260 m/s ΔV with 2646 kg of propellant
- Five MMRTGs would provide 540 W (EOM) with batteries for peak modes
- Rad-hardened electronics with shielding to survive 2.9 Mrad (behind 100 mil Al) environment
- 9-year lifetime
- Healthy mass and power margins (43%, >33% respectively)

JEO incorporates minor modifications to a strong EE2007 design

JEO Flight System Block Diagram



JEO Mass Summary

JEO Baseline Mass Equipment List	Flight System Mass, kg		
	CBE	Cont.	CBE+Cont.
Payload	**163**	**30%**	**211**
Model Payload	106	30%	137
Payload Radiation Shielding	57	30%	74
Spacecraft	**1208**	**24%**	**1498**
Power (w/o RPSs)	55	30%	72
C&DH	34	17%	40
Telecom	56	27%	70
Structures & Mechanisms	320	31%	420
Thermal	68	30%	88
Propulsion	157	28%	201
AACS	69	33%	91
Cabling	83	30%	108
Radiation Monitoring System	8	30%	10
RPS System	226	0%	226
Spacecraft Radiation Shielding	132	30%	172
Flight System Total Dry	**1371**	**25%**	**1709**
Additional System Margin to achieve study req.			226
Flight System Total Dry with Required Margin			**1935**
Propellant			2646
Flight System Total Wet			**4581**
LV Adapter with required margin			123
Flight System Launch Mass Wet			**4704**
Atlas V 551 Capability for 2020 VEEGA			**5040**
Additional Margin			**336**
System Margin (33% required per study guidelines)			**43%**

Payload and Shielding

5 MMRTGs

S/C Radiation Shielding for 2.9 Mrad

Delta V of 2260 m/s

Very Healthy Margins

Calculating Dry Mass Margin per Study Guidelines:

Dry Mass Allocation (MPRV)
= LV Capability – Prop–*RTG Mass**
= 5040 – 2646 – 226 = 2168 kg

Dry Mass CBE (PRV)
= S/C CBE + LV Adapt–*RTG Mass**
= 1371 + 82 – 266 = 1227

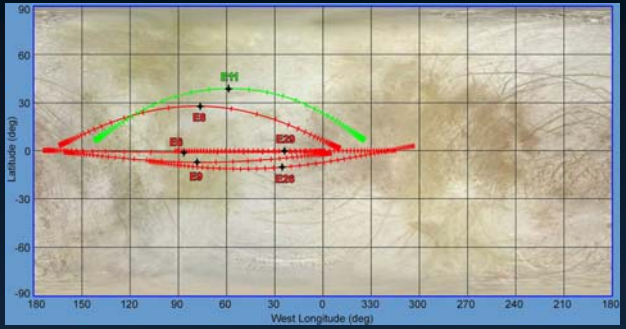
Dry Mass Margin

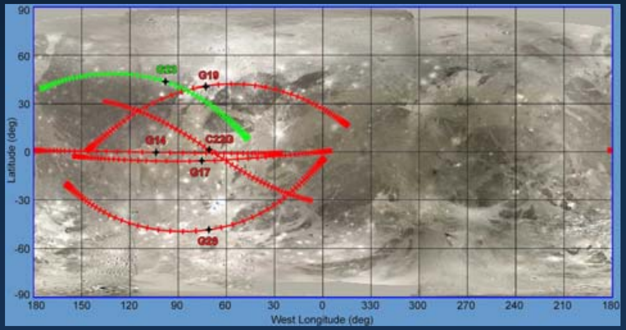
= (MPRV – PRV)/MPRV
= (2168 – 1227)/2168 = <u>43%</u>

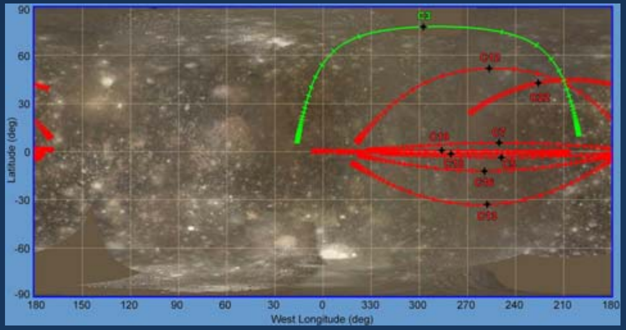
**Note: The MMRTG mass is considered a Not-To-Exceed Mass, and is therefore excluded from the margin calculations, per HQ direction.*

JEO's design is robust to future changes due to large mass margins

Jupiter System Science



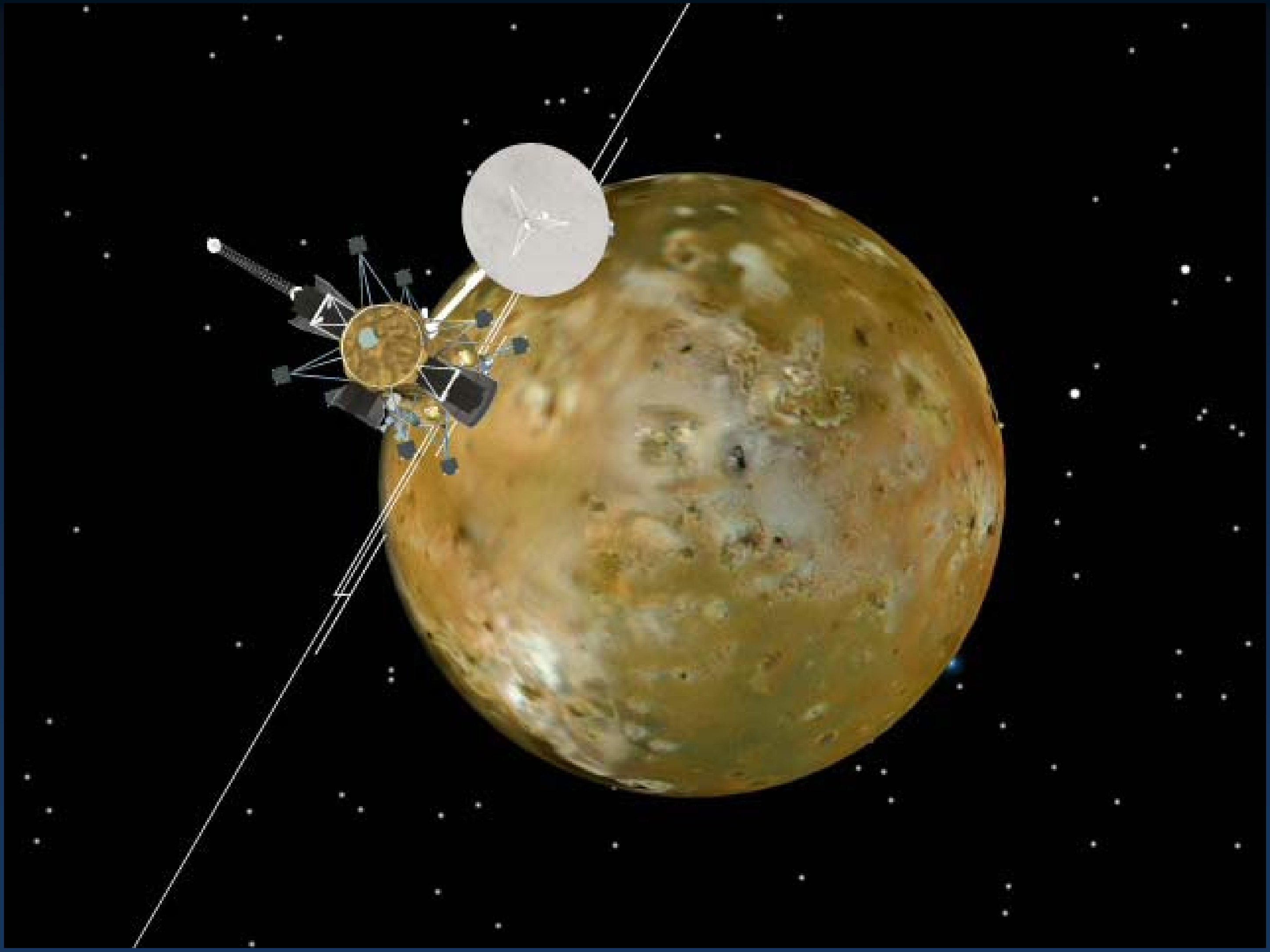




- Jupiter and Io monitoring, atmospheres, magnetospheres, rings and small bodies
- Satellite science
  - Io: 3 flybys
    - Opportunities for imaging, IR spectroscopy, and altimetry
    - In situ analysis of extended atmosphere with INMS at 75 km
  - Europa: 6 flybys
    - Radar and altimetry characterization and calibration
    - Imaging at up to 10–50 m resolution, NIR 250–1250 m
  - Ganymede: 6 flybys
    - Radar sounding of grooved and dark terrains
    - Range of lats, lons for magnetosphere sampling
  - Callisto: 9 flybys
    - High-latitude flyby for gravity field determination
    - Ocean characterization with magnetometer
    - Radar for subsurface structure of ancient cratered terrain

Satellite	≤1000m	≤200m	≤50m	≤10m	Length IPR (km)	Length LA (km)
Io	30%	20%	5%	-	1000	7400
Europa	60%	60%	15%	0.01%	6600	19000
Ganymede	50%	50%	10%	0.02%	17000	28000
Callisto	85%	75%	5%	0.01%	15000	30000

Io Flyby Example



Europa Science Campaigns

JOI to EOI	Jul 2028	Aug 2028	Sep 2028	Oct 2028

Satellite/Jupiter Science

Observing Strategies for Europa Campaigns 1–3

- Always on: LA, MAG, PPI, TI, INMS (50%)
- 2-orbit ops scenario permits power/data rate equalization:
  - Even orbits emphasize optical remote sensing:
  - Odd orbits emphasize radar sounding to locate water
- Targets collected with residual data volume

Eng Assessment (6 d)

Initial Europa Orbit

Altitude: 200 km
Inclination: 95–100 deg (~85° N lat)
Lighting: 2:30 PM LST
Repeat: 4 Eurosols

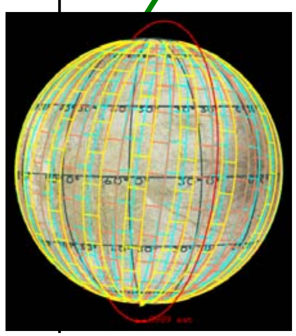
After Campaign 1

Altitude: 100 km
Repeat: 6 Eurosols

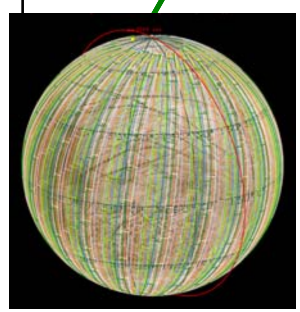
Europa Science Campaigns

1A | 1B | 2A | 2B | 3 | 4

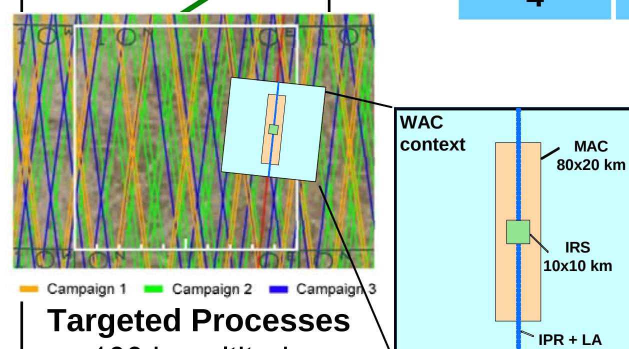
Europa Campaigns 1–3 total 99 days



Global Framework
200 km altitude
(200 m/pixel WAC)
8 eurosols ≈ 28 days



Regional Processes
100 km altitude
(100 m/pixel WAC)
12 eurosols ≈ 43 days



Targeted Processes
100 km altitude
8 eurosols ≈ 28 days

Paving the Way for a Future Lander

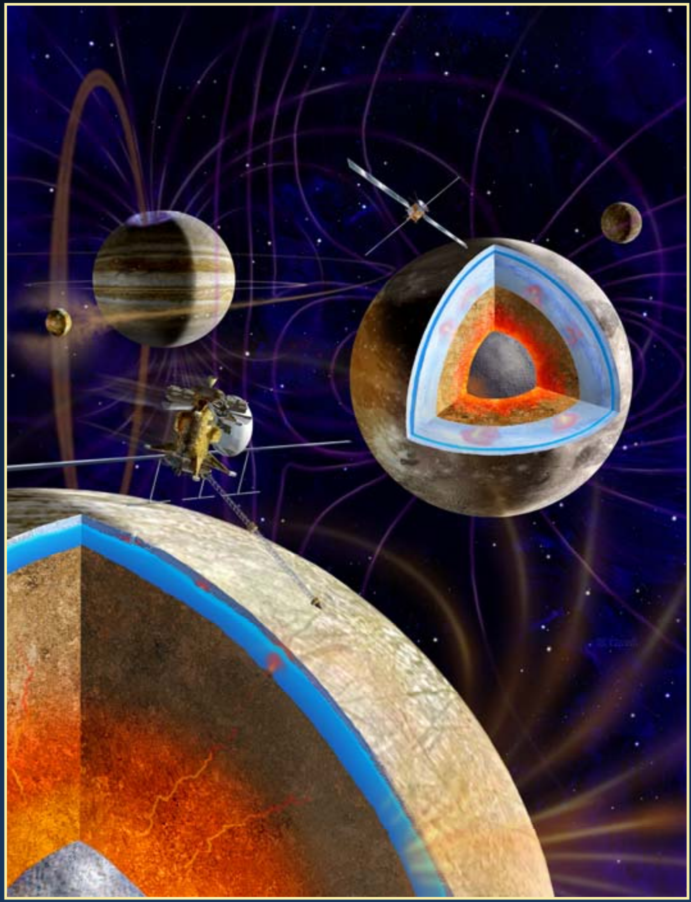
- *Best for Science* - Recent material exchange with subsurface (i.e. young in age) and rich in chemistry
  - High resolution imaging, radar, IR spectroscopy, thermal imaging

- *Safe for landing* - Meter scale topography, heterogeneity, depth and porosity of regolith
  - High resolution imaging, laser altimetry, radar, thermal inertia
  - Fine scale processes: mass wasting, sputter erosion, sublimation, impact gardening, frost deposition

Europa Jupiter System Mission

NASA Jupiter Europa Orbiter + ESA Jupiter Ganymede Orbiter

- EJSM Study
  - International team, shared leadership
  - Built on previous studies
  - Community involvement
- Scientifically rich
- Well-defined, mature science
- Exploration opportunities
- Technology/mission design mature



EJSM is well defined and ready to go!

Predecisional, For Planning Purposes Only