JUICE: Mission Overview and Study Status

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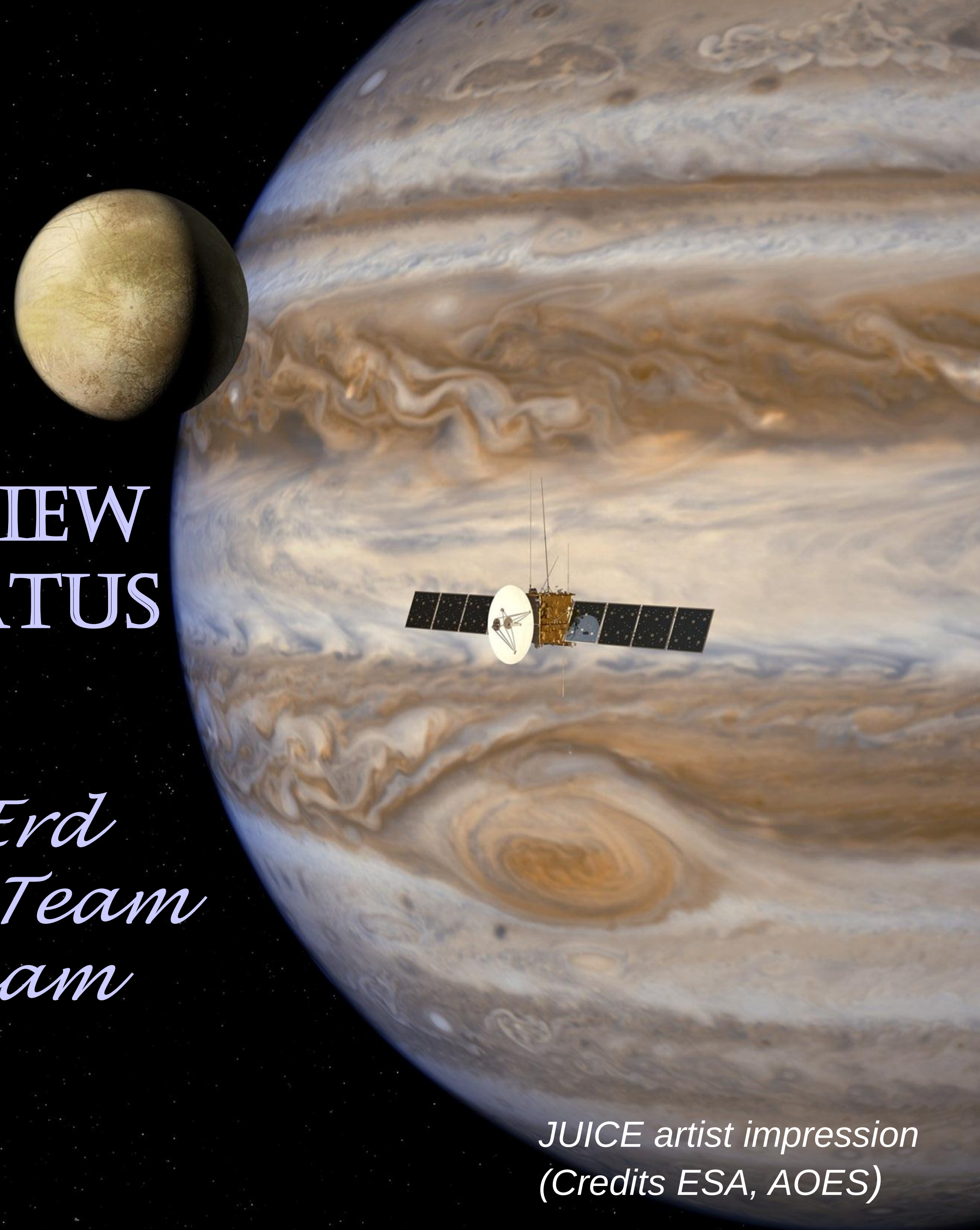
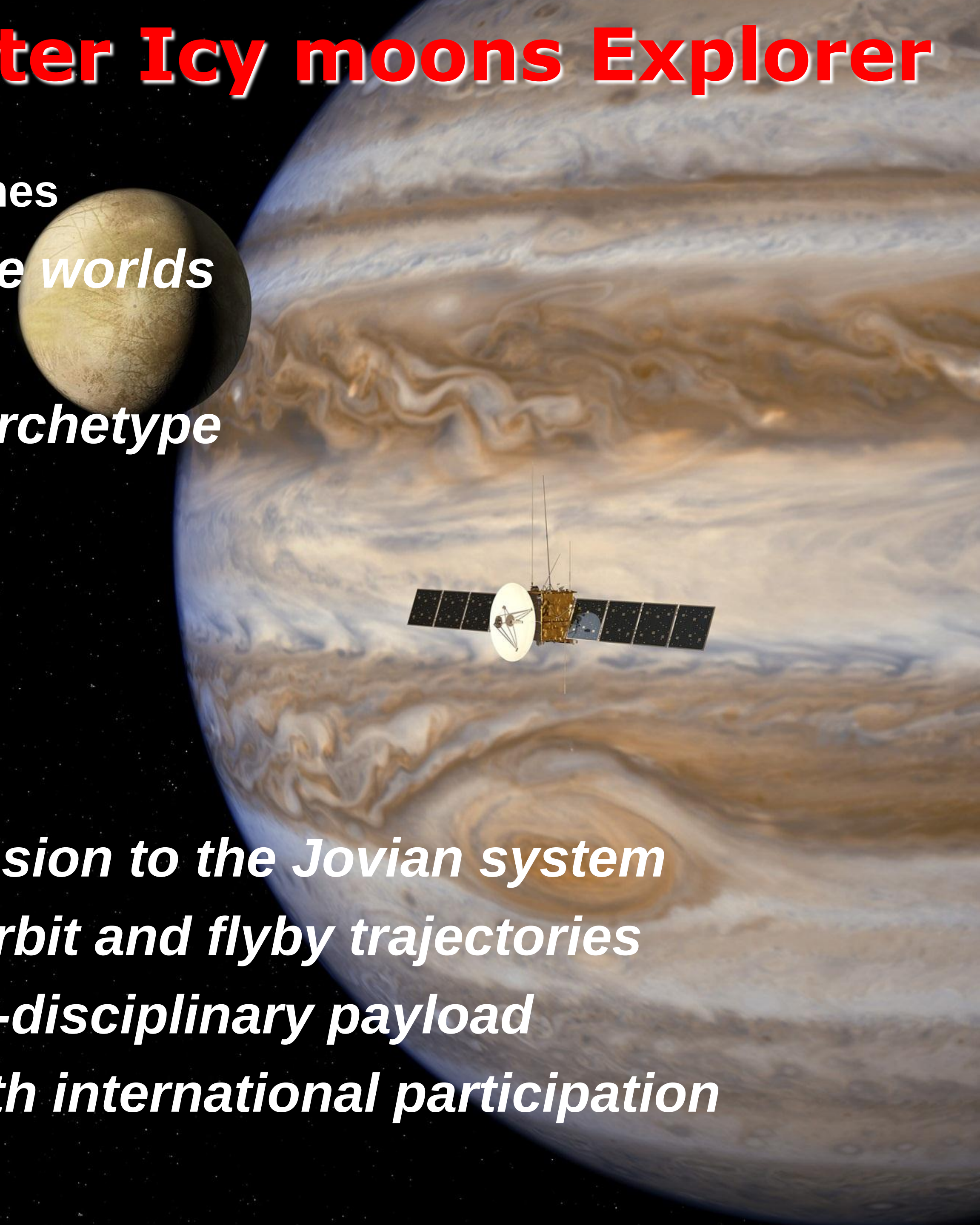
JUICE Science Team
ESA Study Team



JUICE artist impression
(Credits ESA, AOES)

JUICE: JUpiter Icy moons Explorer



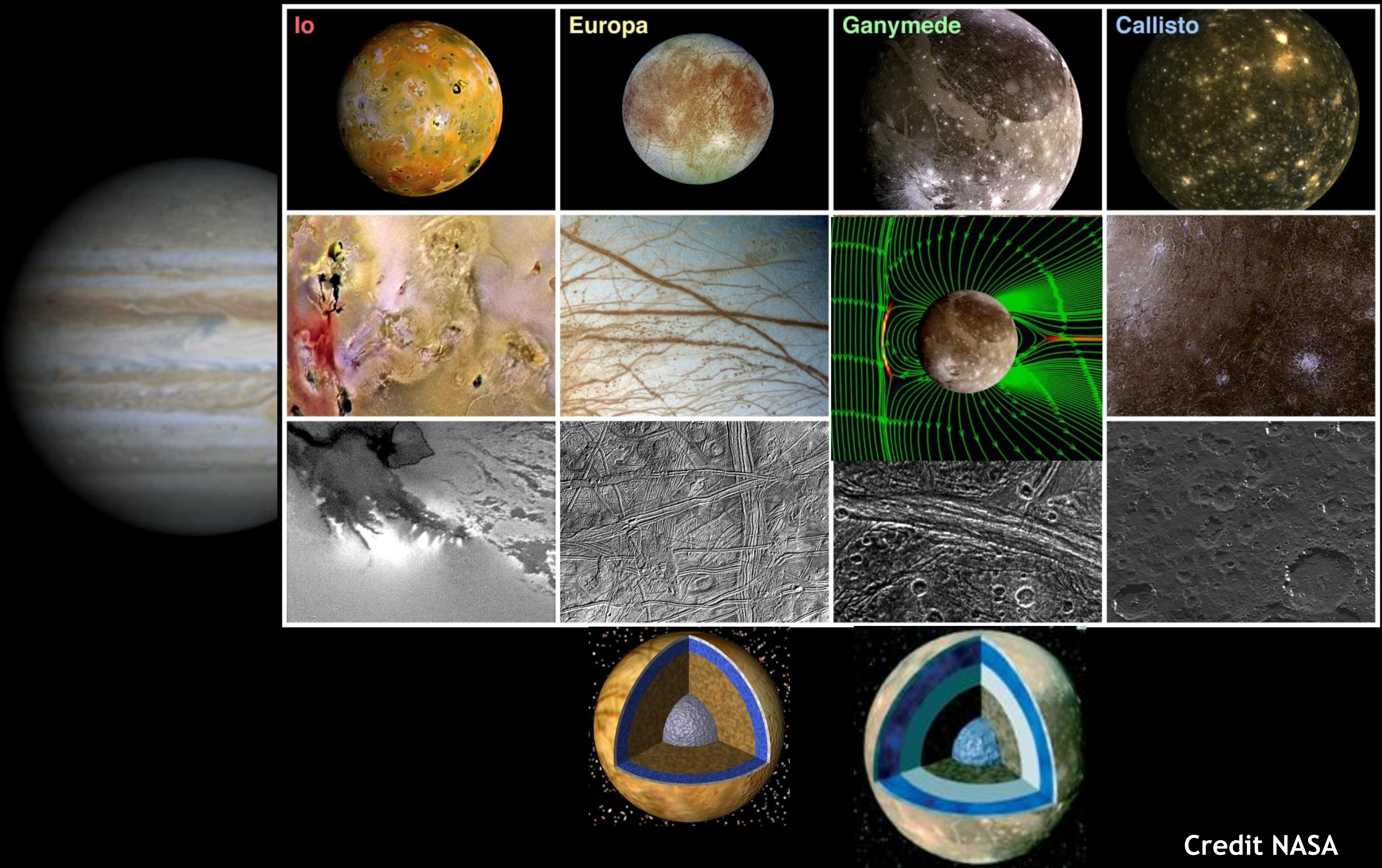
JUICE Science Themes

- *Emergence of habitable worlds around gas giants*
- *Jupiter system as an archetype for gas giants*

JUICE concept

- *Single spacecraft mission to the Jovian system*
- *Investigations from orbit and flyby trajectories*
- *Synergistic and multi-disciplinary payload*
- *European mission with international participation*

Jupiter family

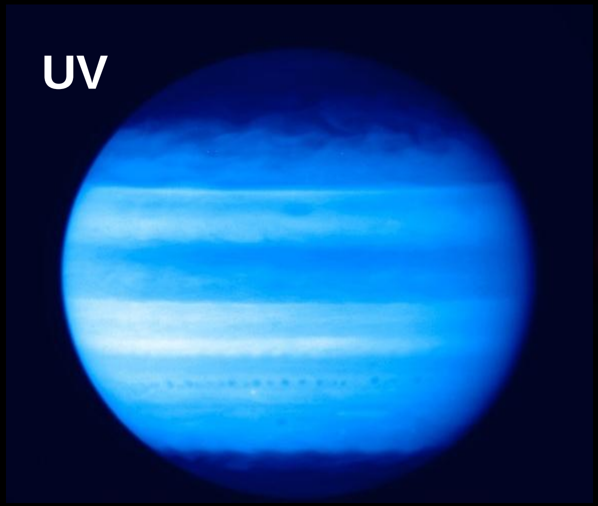


Credit NASA

Jovian atmosphere

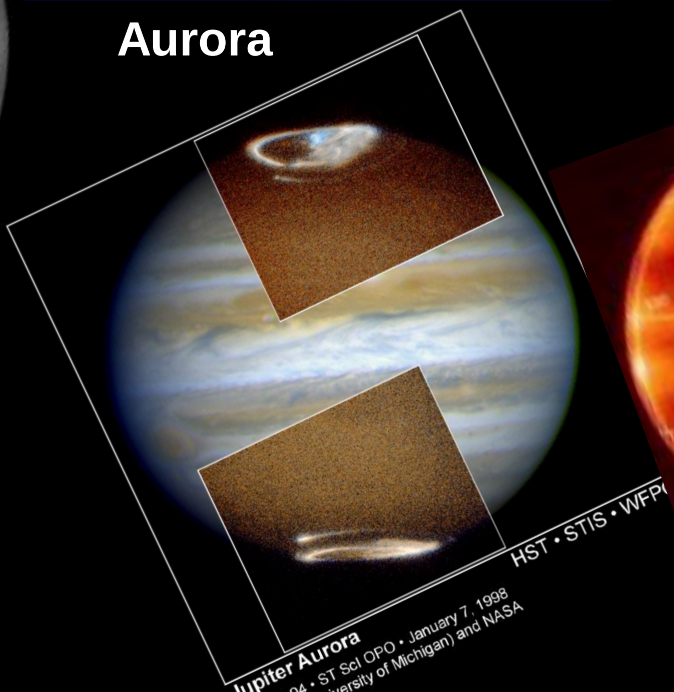
Visible

UV

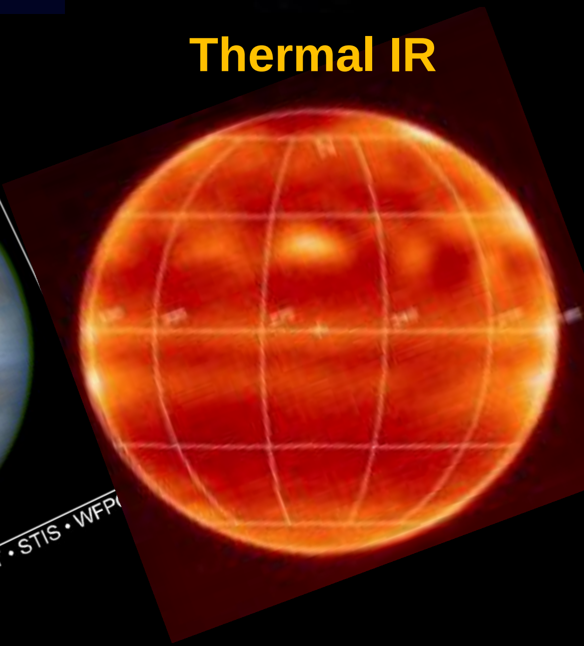


Near-IR

Aurora

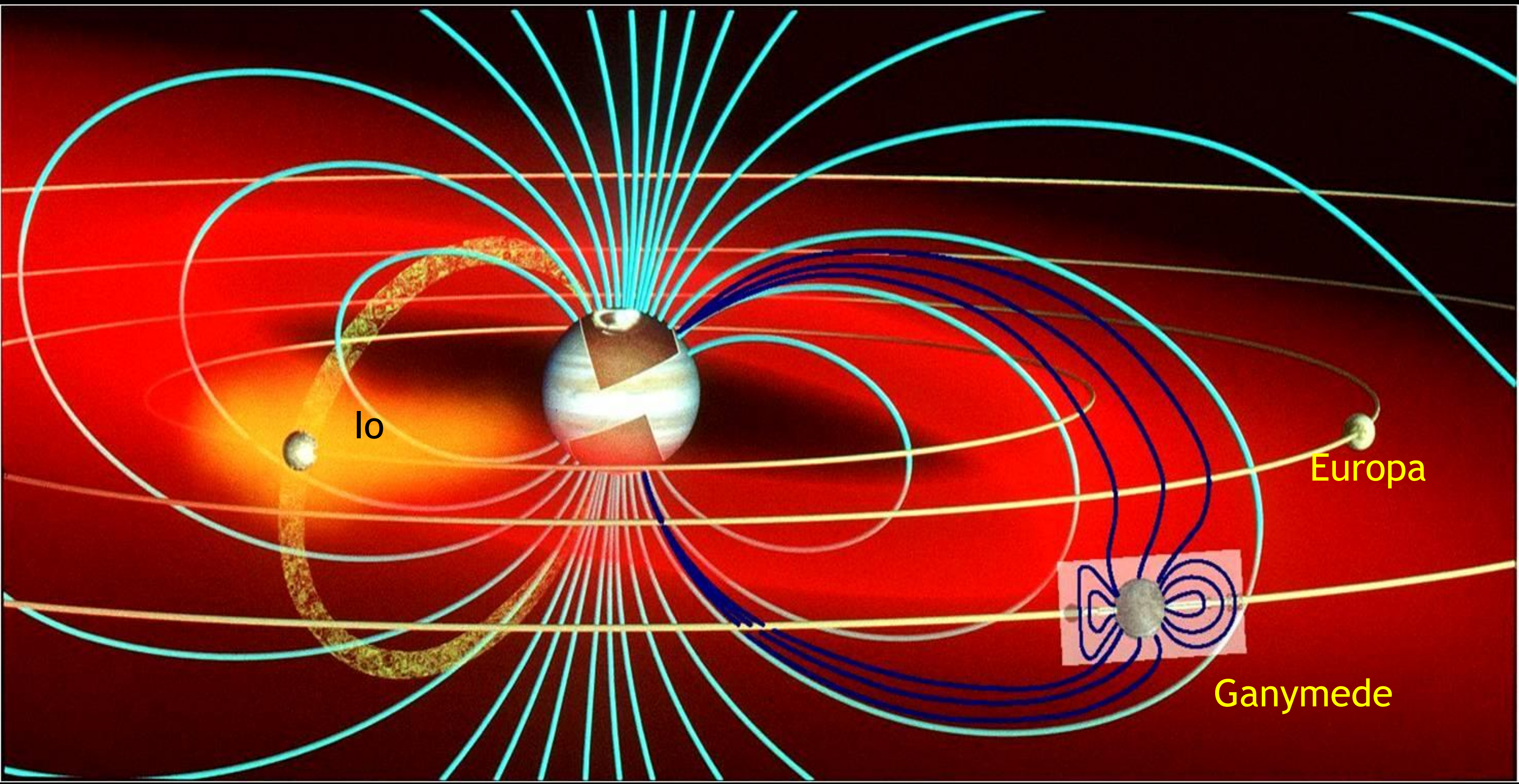


Thermal IR



Credit HST, NASA

Jovian magnetosphere



JUICE Payload

Acronym	PI	LFA	Instrument type
Remote Sensing Suite			
JANUS	P. Palumbo	Italy	Narrow Angle Camera
MAJIS	Y. Langevin G. Piccioni	France Italy	Vis-near-IR imaging spectrometer
UVS	R. Gladstone	USA	UV spectrograph
SWI	P. Hartogh	Germany	Sub-mm wave instrument
Geophysical Experiments			
GALA	H. Hussmann	Germany	Laser Altimeter
RIME	L. Bruzzone	Italy	Ice Penetrating Radar
3GM	L. Iess	Italy	Radio science experiment
PRIDE	L. Gurvits	Netherlands	VLBI experiment
Particles and Fields Investigations			
PEP	S. Barabash	Sweden	Plasma Environmental Package
RPWI	J.-E. Wahlund	Sweden	Radio & plasma Wave Instrument
J-MAG	M. Dougherty	UK	Magnetometer

Payload: Remote sensing suite

Acronym	Instrument type	Characteristics
JANUS	Imaging system	• 350-1050 nm, 13 filters • FOV: 1.72x1.29 ° • 3 m/px at Ganymede (from 200 km orbit) • 15 km/px at Jupiter (from Ganymede orbit)
MAJIS	Vis-near-IR imaging spectrometer	• 0.4-5.7 µm, 3-7 nm resolution • FOV: 3.4° • 0.025km/px at Ganymede (from 200 km orbit) • 125 km/px at Jupiter (from Ganymede orbit)
UVS	UV spectrograph	• 55-210 nm, <0.6 nm resolution • 0.5 km/px at Ganymede(200 km) • 250 km/px at Jupiter
SWI	Sub-mm wave instrument	• 530-601 GHz (500 µm) • 10^7 resolving power • 30 cm antenna, 1-2 mrad resolution

Payload: Geophysical experiments

Acronym	Instrument type	Characteristics
GALA	Laser Altimeter	• 30 & 75 shot frequency • Resolution H/V: 10 m/ 0.1 m at Ganymede (200km)
RIME	Ice Penetrating Radar	• 9 MHz (1&3 MHz band) • 10 m antenna • down to 9 km depth • 30 m resolution in ice
3GM (USO+KaT)	Radio science experiment	• Gravity field up to degree 10 at Ganymede • Structure of the Jupiter atmosphere 0.1-800 mbar
PRIDE	VLBI experiment	Lateral position of s/c with ~25 m accuracy

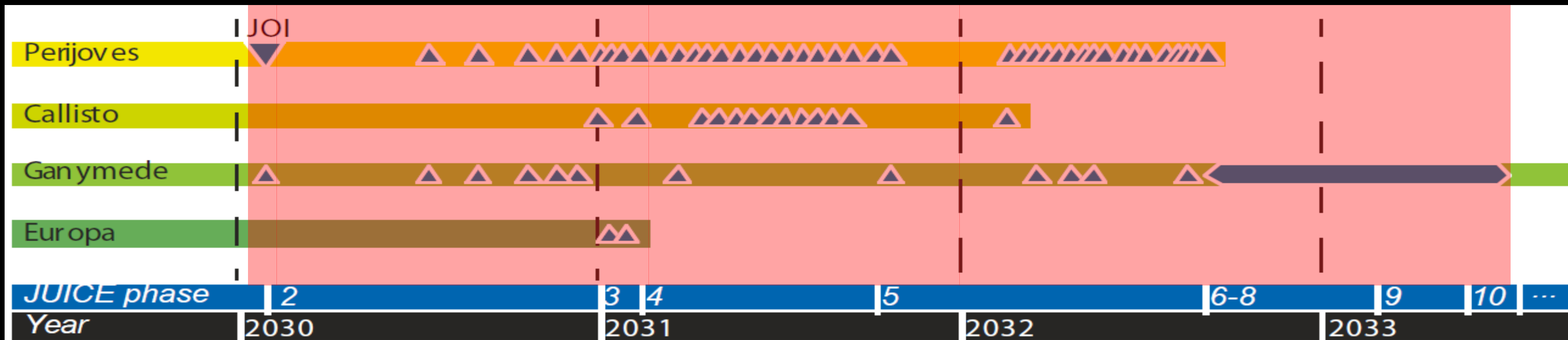
Payload: in-situ plasma & fields package

Acronym	Instrument type	Characteristics
PEP	Plasma Environmental Package	• 6 sensors • Neutrals, ions, electrons • Energy range <0.001 eV to >1 MeV • Composition with mass range 1-1000 amu and M/dM > 1100
RPWI	Radio & plasma Wave Instrument	• 4 sensors • E-field : DC - 45 MHz • B-field : 0.1 Hz – 20 kHz • Plasma properties: N_e, N_i, T_e,V_i • Dust characterization (>1 µm)
J-MAG	Magnetometer	• Measurements rate 32 Hz, 128 Hz • ±8000 nT @ 1 pT resolution • ±50000 nT @ 6 pT resolution

Mission scenario overview

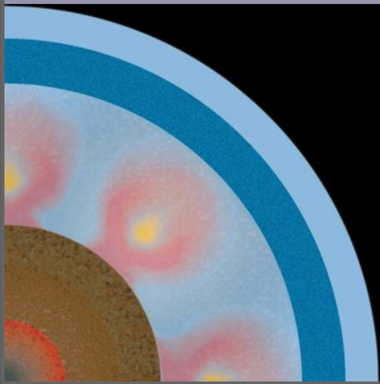
Launch	06.2022
1. Interplanetary Transfer	7.6 years
Jupiter Orbit Insertion	01.2030
2. Jupiter equatorial phase #1	~11 mon
3. Two Europa flybys	36 days
4. Jupiter high-latitude phase including Callisto flybys	260 days
5. Jupiter equatorial phase #2	~11 mon

Ganymede phases	
6. Elliptic #1	30 days
7. High altitude (5000 km)	90 days
8. Elliptic #2	30 days
9. Circular (500 km)	102 days
10. Circular (200 km)	30 days
Total mission duration	11 years

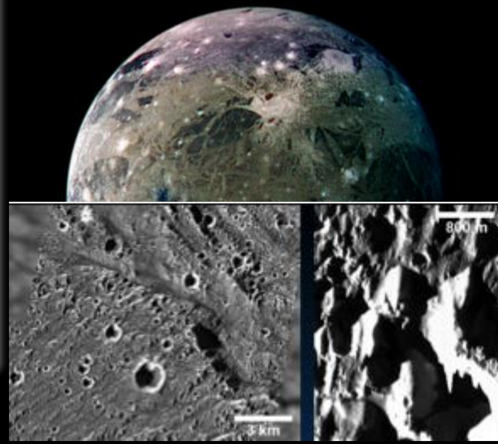


Ganymede: planetary object and potential habitat

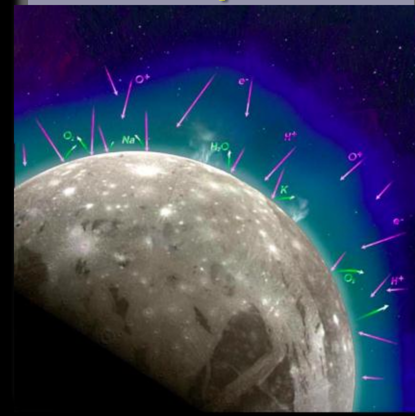
Ice shell, ocean, deeper interiors



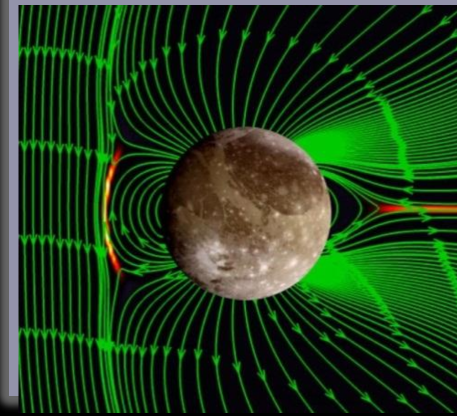
Geology, surface composition



Atmosphere, ionosphere



Magnetosphere, plasma environment



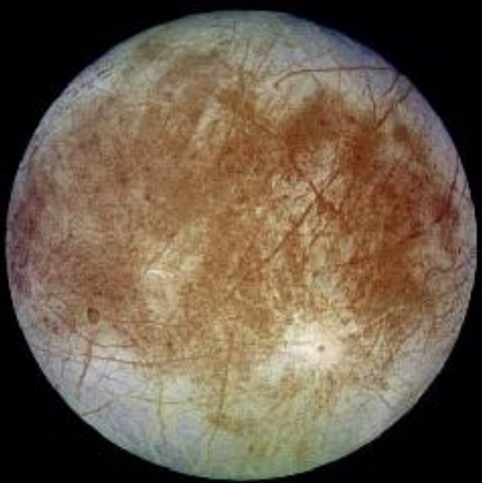
Main investigations

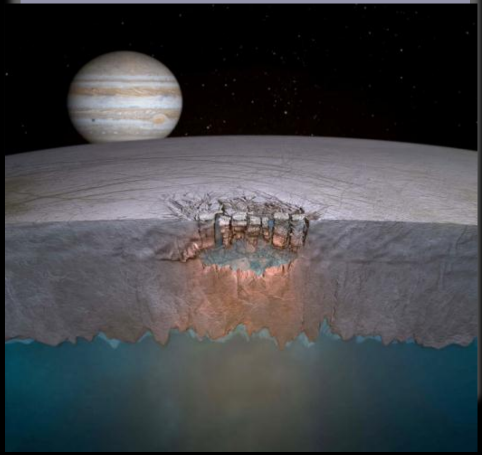
- *Imaging: global ~400 m/px, selected targets ~3 m/px*
- *Mineralogical mapping (especially of non-ice materials): globally 1-5 km/px , selected targets ~25 m/px*
- *Thickness of the icy crust, ocean depth and conductivity*
- *Sub-surface sounding down to ~9 km depth*
- *Composition and dynamics of the atmosphere*
- *Magnetosphere, plasma environment, and interaction with the surface and the Jovian magnetosphere*

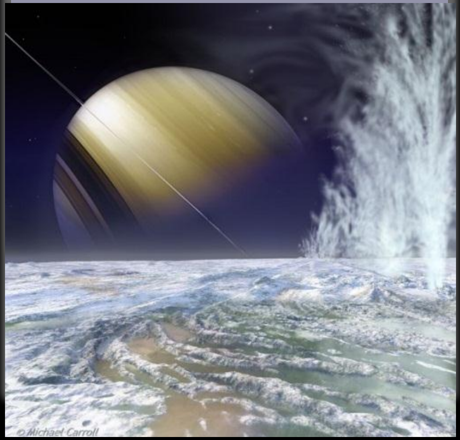
Credit NASA

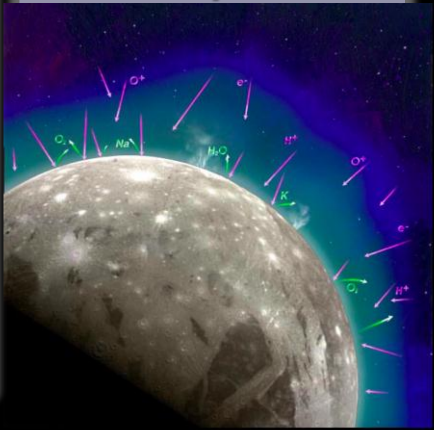
Europa: study of recently active regions

Composition of non-ice material	Liquid sub-surface water	Active processes	Atmosphere, ionosphere







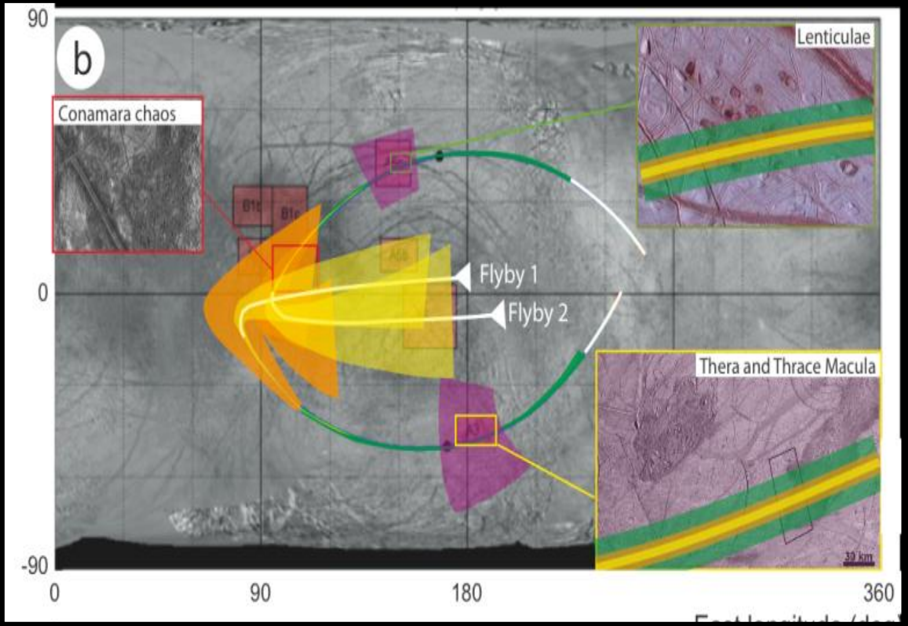


Credit NASA

Main investigations

- ***Non-ice materials in selected sites mapped at regional (>5km/px) and local (<500 km/px) scales***
- ***Context imaging (< 500 m/px)***
- ***Search for liquid water in the shallow (few km) subsurface***
- ***Processes in active sites***
- ***Atmosphere and plasma environment***

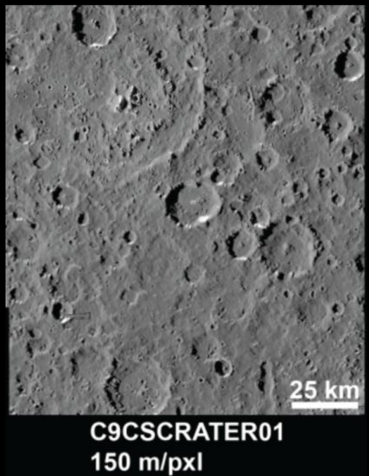
Geometry of two baseline Europa flybys



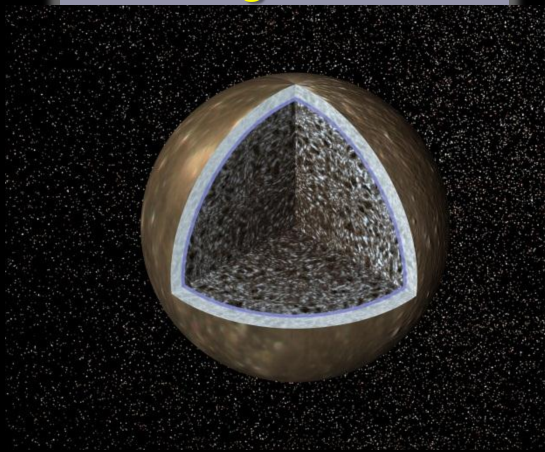
Callisto: a witness of the early Solar System

Geological history and past activity

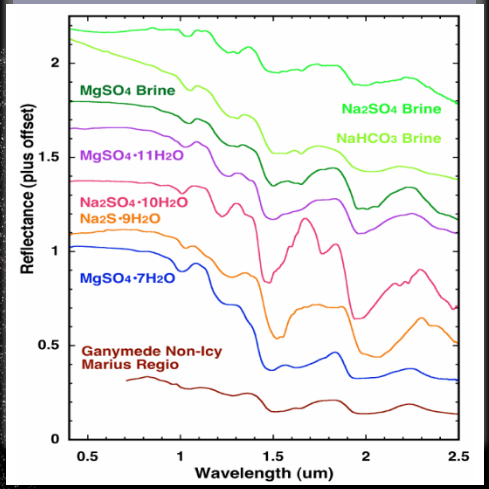
Credit NASA



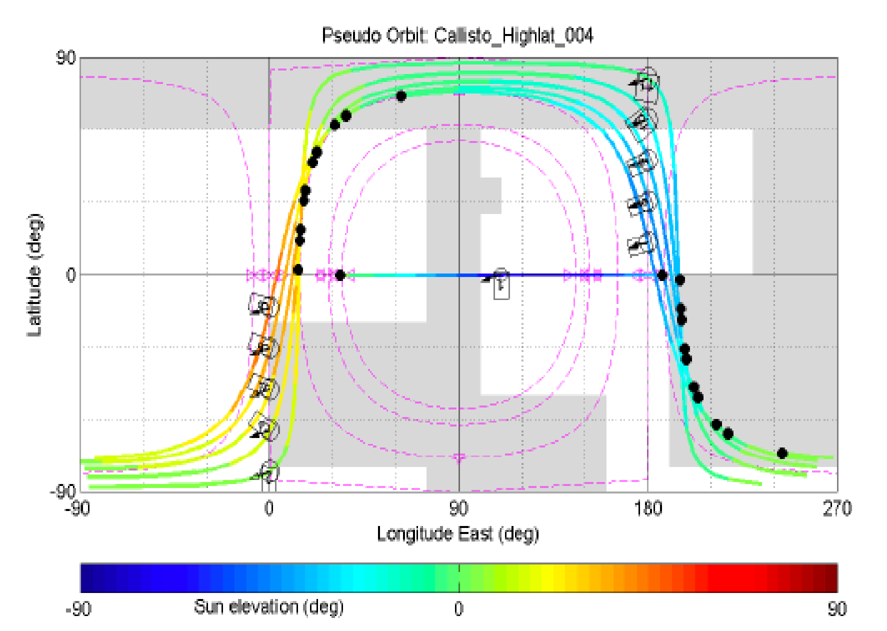
Outer shell including ocean



Non-ice material



Geometry of the baseline Callisto flybys

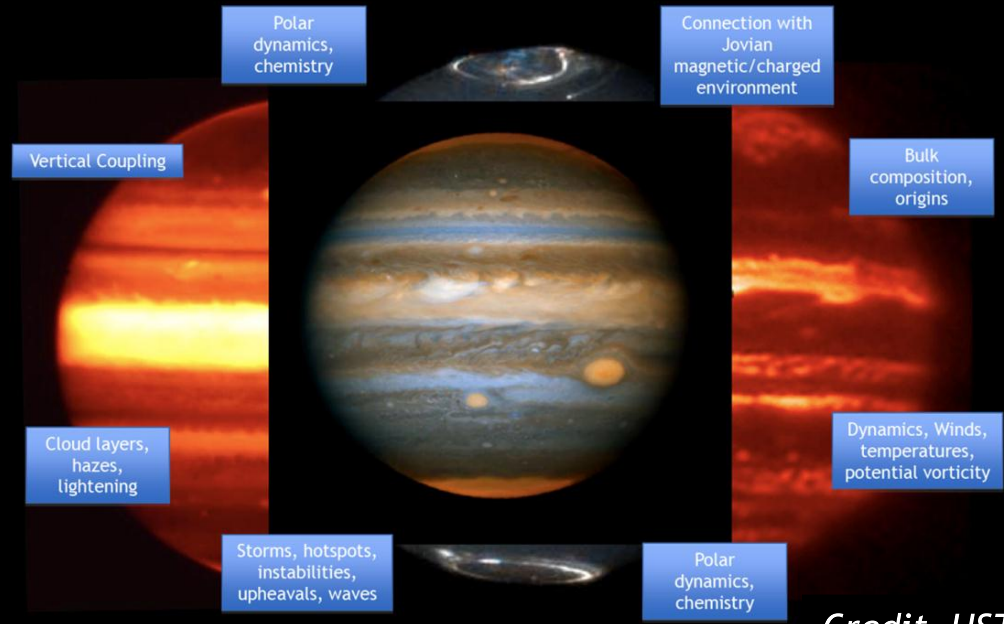


Main investigations

- ***Medium resolution imaging (<400m/px)***
- ***Regional mineralogical mapping (~5km/px)***
- ***Outer shell including the ocean***
- ***Subsurface down to few km***
- ***Exosphere and weathering processes***

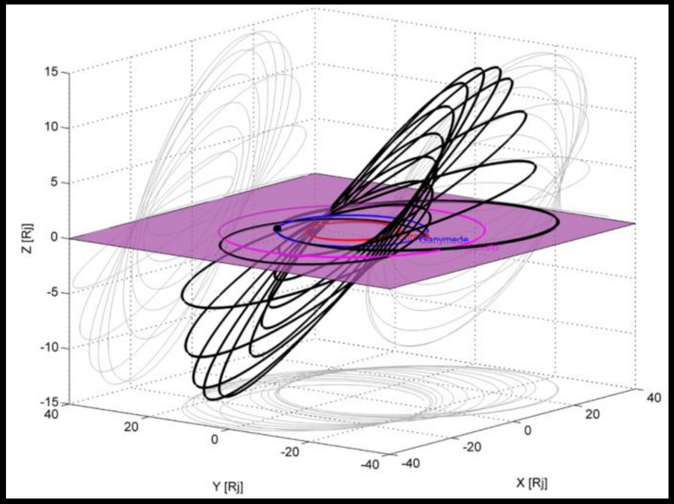
Jupiter atmosphere

- *Atmospheric structure, composition and dynamics*
- *Coupling between troposphere, stratosphere and thermosphere*



Credit HST

High-inclination trajectories

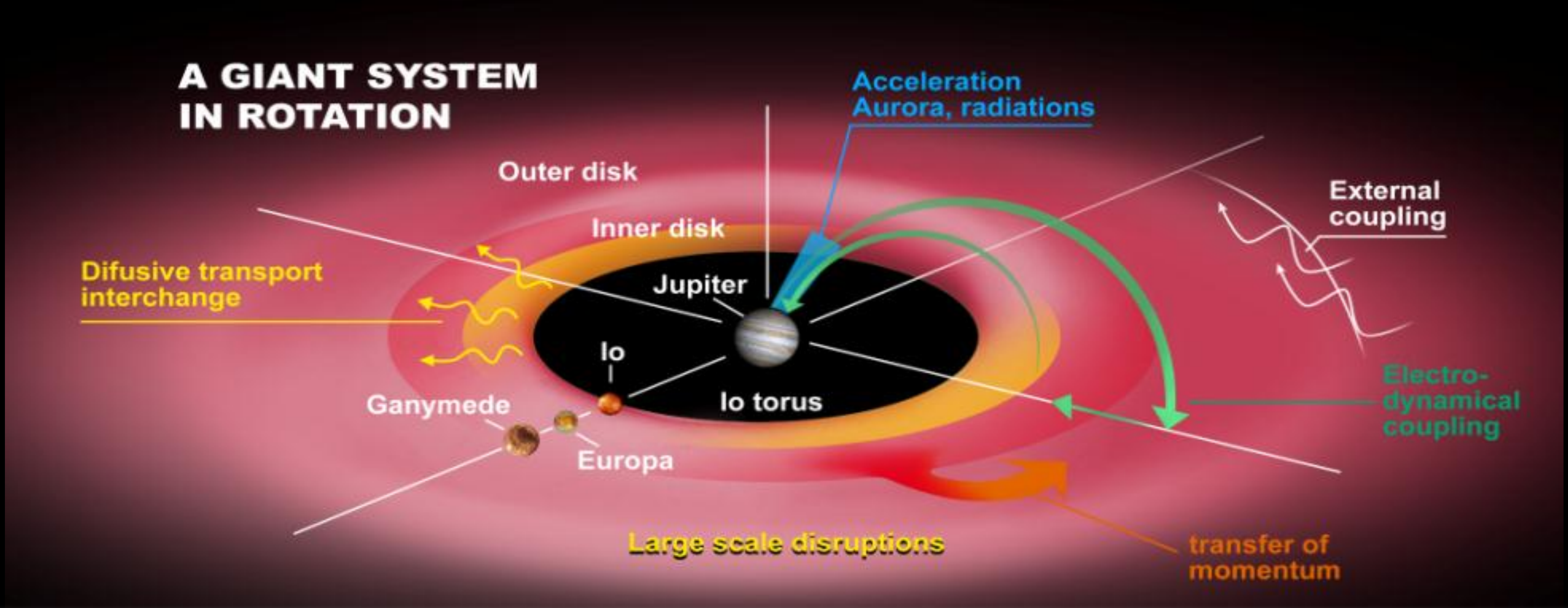


Main investigations

- ***Multi-wavelength observations from UV to sub-mm***
- ***Imaging ~15 km/px, spectro-imaging 100-200 km/px***
- ***Complete latitude, phase angle, local time coverage***
- ***Repeated observations with time scales from hours to months***
- ***Extended period of time (3 years in total)***

Jupiter magnetosphere

- *Magnetosphere as a fast rotator*
- *Magnetosphere as a giant particle accelerator*
- *Interaction of the Jovian magnetosphere with the moons*
- *Moons as sources and sinks of magnetospheric plasma*

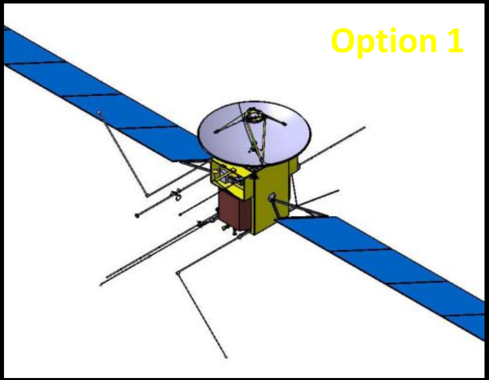


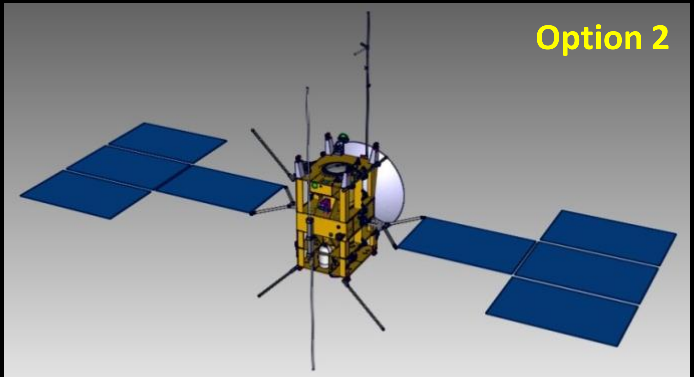
Main investigations

- *Equatorial magnetosphere at R ~ 10 - 30 R_J and out to at least 100 R_J*
- *High-inclination orbit (up to at least 30°)*
- *Simultaneous remote sensing and in-situ observations*

Main features of the spacecraft design
(end of assessment phase)

- **Dry mass ~1900 kg, propellant mass ~2900 kg**
- **High Δ*v* required: 2600 m/s**
- **Payload ~105 kg, ~ 150 W**
- **3-axis stabilized s/c**
- **Power: solar array ~ 80 m^2, ~ 800 W**
- **HGA: >3 m, fixed to body, X & Ka-band**
- **Data return >1.4 Gb per day**



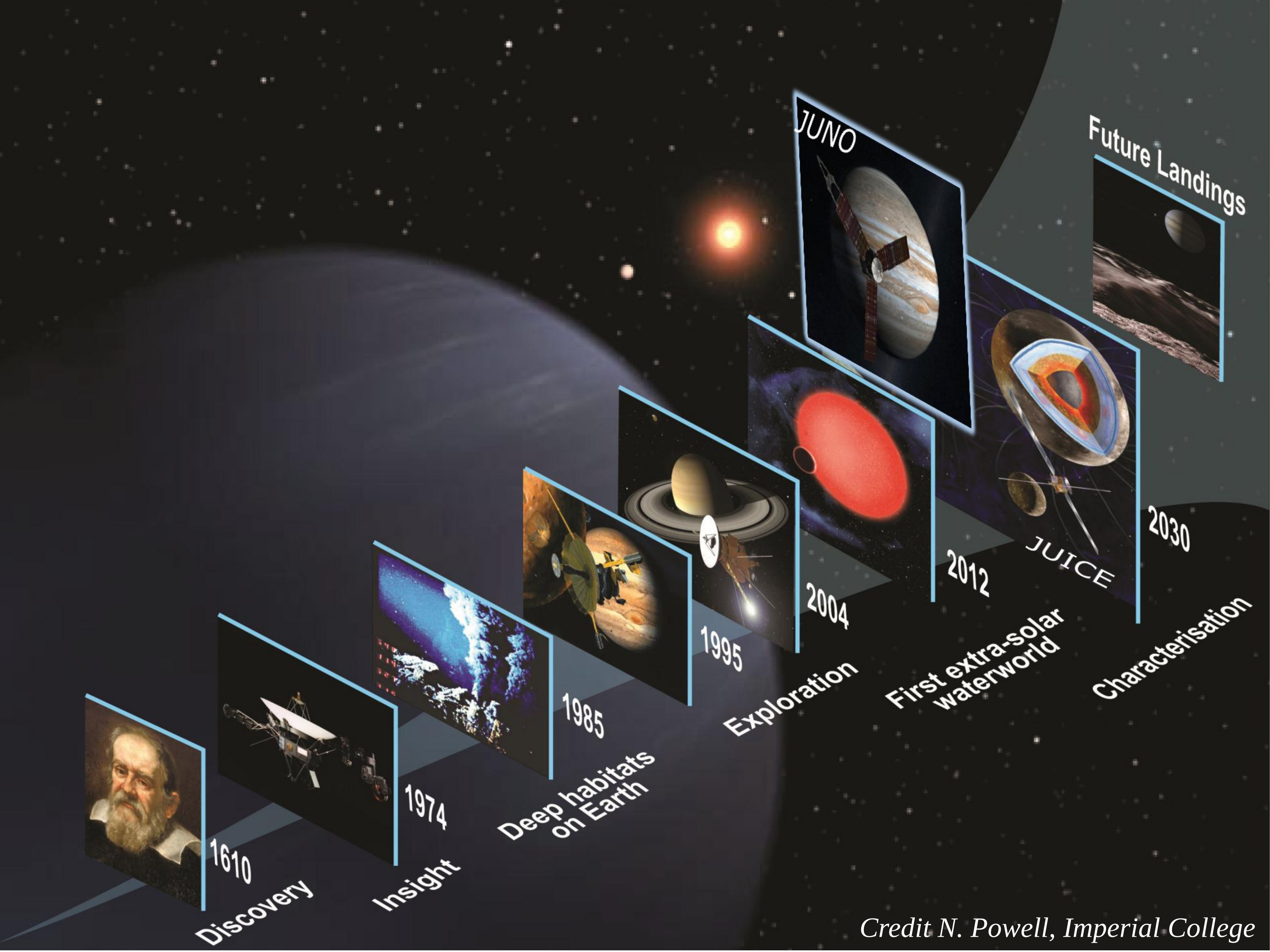


Status of the mission study

1. **JUICE is in the middle of the Definition Phase (A/B1)**
2. **11 experiments are selected**
3. **Two industrial contractors**
4. **Preliminary Requirements Review (December 2013 – April 2014)**
    - ***Verify definition, completeness, and flow down of science requirements***
    - ***Confirm the feasibility of the proposed spacecraft and mission implementation***
    - ***Verify the preliminary instruments and external spacecraft interfaces***
    - ***Review the science operations concept and the ground segment design***
    - ***Verify that the planning, schedule, and costs are realistic***
    - ***etc***
5. **Planned future work**
    - ***System requirements review (August-September 2014)***
    - ***Mission adoption (November 2014)***
    - ***Selection of industrial contractor (mid-2015)***
    - ***Start of the implementation phase (end 2015)***

Conclusions

- **ESA-led mission with broad international participation to the outer Solar system**
- **First orbiter of an icy moon**
- **Highly capable spacecraft with synergistic and multi-disciplinary payload**
- **Detailed study of two classes of planetary objects**
    - *a gas giant*
    - *an icy moon*
- **Comparative study of the icy moons family**
- **Investigations of two classes of planetary atmospheres**
    - *well developed atmosphere of the gas giant*
    - *tenuous exospheres of the icy moons*
- **Magnetosphere and plasma environment of the gas giant and its interaction with its moons**
- **Couplings within the Jovian system**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Future Landings
1610
Discovery
1974
Insight
1985
Deep habitats on Earth
1995
Exploration
2004
2012
First extra-solar waterworld
JUICE
2030
Characterisation
Credit N. Powell, Imperial College