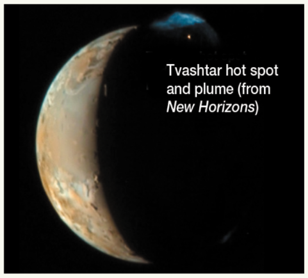
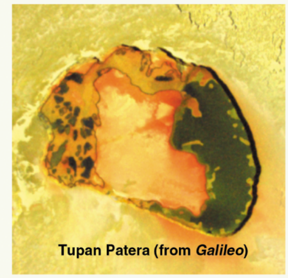
Io Volcano Observer

Investigating the Solar System's most volcanically active world



Io, the innermost of four large Galilean moons of Jupiter, is the most tidally heated and volcanically active world in the Solar System. The enormous volcanic eruptions, active tectonics, and high heat flow are like those of ancient terrestrial planets and present-day extrasolar planets. Powered by advanced solar array technology, IVO's dedicated mission design and optimized payload of remote sensing and particle and fields measurements will transform our understanding of this unique world.



Tupan Patera (from *Galileo*)

PI: Alfred McEwen, University of Arizona
Mission Implementation: JHU/APL

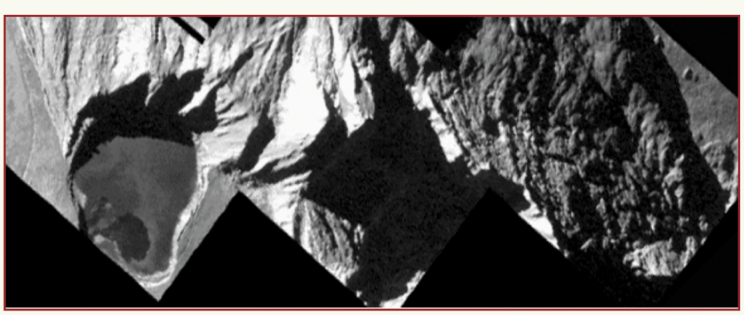
Impact and Relevance:

IVO addresses major themes identified in the 2011 Decadal Survey for Planetary Science:

- **Workings of Solar Systems.** Hyperactive Io is ideal for studying planetary processes, including volcanism, tectonism, tidal dissipation, SO_2 atmospheric dynamics, and magnetospheric interactions.
- **Planetary Habitats.** Tidal heating driving Io's activity controls the Jovian system's habitable zone, and understanding it gives insight into potential habitats in extrasolar planetary systems.
- **Building New Worlds.** Voluminous and high-temperature volcanic and interior processes active on Io help us understand analogous very early processes on the Earth, Moon, Mercury, Venus, and Mars.

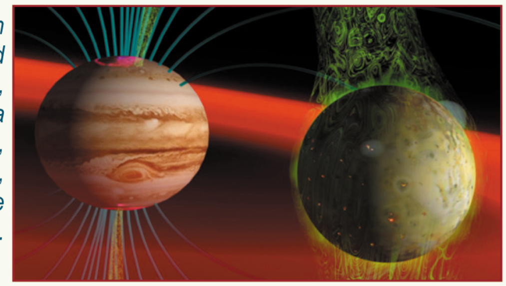
Science Objectives and Key Measurements:

Objectives (Gain Understanding of)	Key Measurements
A1. Io's active volcanism	High-resolution repeat imaging at UV to thermal-IR wavelengths.
A2. State of Io's interior & implications for tidal heating	Measure peak lava temperature for mantle temperature & electromagnetic induction signal from mantle melt. Map/monitor global heat flow.
B1. Nature of Io's lithosphere & unique tectonics	Image & measure topography of key tectonic structures.
B2. Connections between Io's volcanism & its surface & atmosphere	Measure mass spectra & temporal & spatial variability of neutral species, & map spectral variations of surface.
B3. Io's mass loss & magnetospheric interactions	Acquire in situ & remote observations of Io's exosphere, sodium cloud, & plasma torus.
B4. Limits to active volcanism on Europa	Distant repeat imaging to search for plumes or surface changes.
C1. Jupiter system science	Observe Jupiter, rings, moons, & magnetosphere.



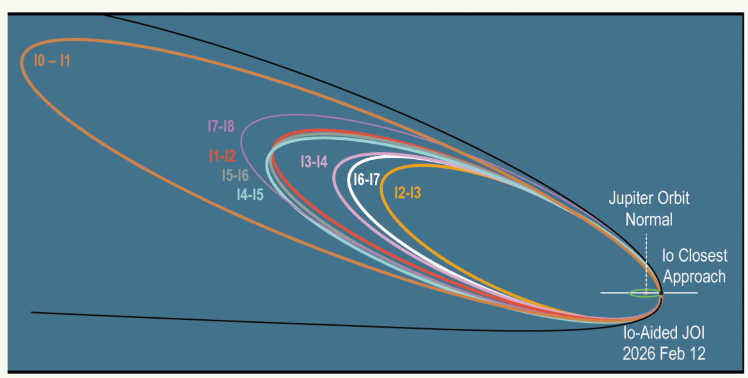
These 50-m/pixel images from Galileo reveal a lava lake in 100-m-deep Radegast Patera (L) and landslides (R) from 9-km-high Tohil Mons (center). IVO will provide >100 times more coverage at ≤50 m/pixel than Galileo.

Io presents a rich array of interconnected orbital, geophysical, atmospheric, and plasma phenomena. It is a bold, yet entirely reachable, new target for the Discovery Program.



Mission Overview:

- Launch May 29, 2021
- ΔV-EGA (Earth gravity assist) trajectory, asteroid flyby opportunities
- Jupiter orbit insertion (JOI) in February 2026 with 500 km Io encounter (I0) and capture into orbit inclined 42° relative to Jupiter's equator
- Eight additional Io encounters over 22 months with high-resolution views of active volcanism in daylight and darkness
- Four of the encounters are designed for optimal measurement of induced magnetic signature from mantle melt
- Mission design minimizes total ionizing radiation dose (372 krad at 100 mil Al, design margin of 2), <10% of that experienced by *Galileo*
- Collect 20 Gb science data per encounter: 100 times the Io data from the 8-year *Galileo* tour; playback near apoapsis
- Encounters last ~1 week, including global monitoring and four Io eclipses
- Nearly polar approach to and departure from Io is ideal for study of polar regions, key to testing tidal heating models



Io Encounter Number	I0	I1	I2	I3	I4	I5	I6	I7	I8
Days since last encounter	0.0	180.4	81.4	49.5	61.9	81.4	81.4	58.4	92.0
Closest approach altitude (km)	510	500	500	500	500	500	500	400	200

IVO's inclined orbit is optimal for key science objectives and results in a much lower Total Ionizing Dose than other Jupiter orbiters.

Science Experiments:

Narrow- and Wide-Angle Cameras (NAC/WAC). NAC: 5 µrad/pixel, 2k × 2k CMOS detector, color imaging (filter wheel + color stripes over detector) in 12 bands from 300 to 1050 nm, framing images for movies of dynamic processes and geodesy. WAC: identical electronics to NAC with 25° FOV for stereo.

Thermal Mapper (TMAP). 640 x 480 detector array and seven spectral band-pass stripes from 5–14 μm, 125 µrad/pixel, for thermal mapping and silicate compositions with bolometer plus a radiometer (7–40 μm).

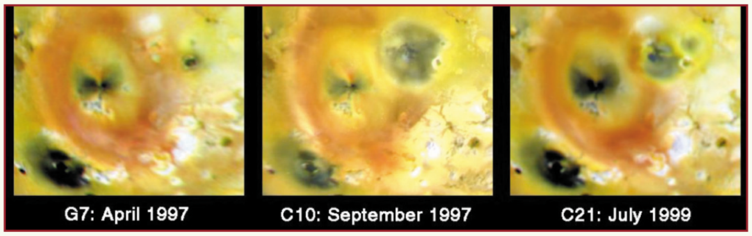
Dual Fluxgate Magnetometers (DMAG). Low-noise sensors, range/sensitivity: 4000/0.01 nT (fine), 65,000/0.12 nT (coarse).

Particle Environment Package for Io (PEPI). *JUICE/PEP* rebuilds with Ion and Neutral Mass Spectrometer (INMS; mass range 1–1000 amu/q, with $M/\Delta M$ = 1100) and Plasma Ion Analyzer (PIA; mass range 1–70 amu, 0.1 to 40 keV).

Gravity Science: 2-way Doppler tracking on I0 and I2, near Io orbital periapse and apoapse, to constrain mantle rigidity.

Student Collaboration (SC) Instrument (optional). Near-Infrared (1.5–2.5 μm), wide-angle (25°) hot spot mapping camera (HOTMAP).

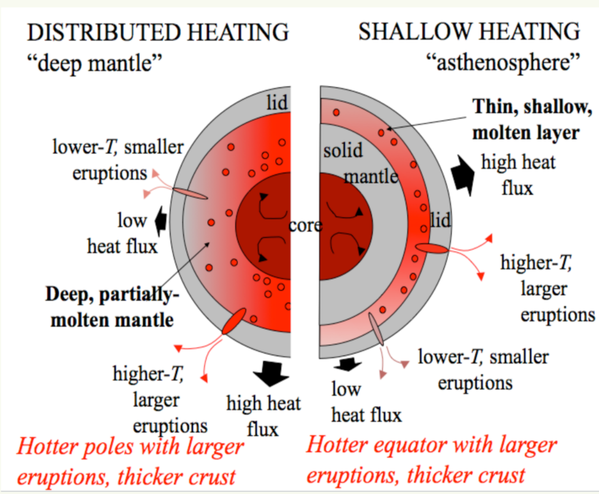
Instrument Mounting. NAC and TMAP on a ± 90° pivot for off-nadir targeting; DMAG sensors on end and middle of 3.8-m boom; PEPI placed for wide FOVs; WAC and HOTMAP on nadir deck.

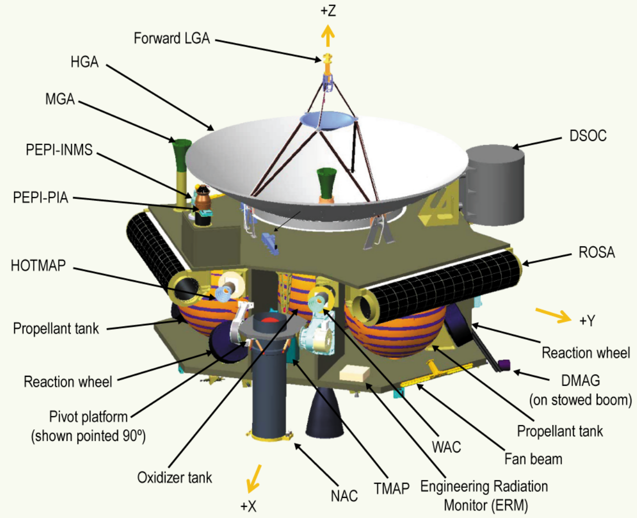


Dedicated Io mission will thoroughly monitor color/albedo changes from volcanic activity.

Typical Science Data Yield from One Orbit:

- Global color imaging at 500 m/pixel and key features at 5–300 m/pixel, plus pole-to-pole WAC stereo color mapping strips
- Imaging of high-temperature activity on night side in 2+ colors at <100 m/pixel to measure liquid lava temperatures
- Near-global (>80%) TMAP coverage at 0.1–10 km/pixel to map heat flow and monitor volcanism
- Movies of active plumes and lava lakes
- Imaging four eclipses per encounter for hot spots and auroral emissions
- Continuous DMAG and PIA measurements with high data rate near Io
- INMS data (~200 spectra) near Io closest approach (C/A) and segments away from Io
- Monitoring of Io, Europa, and Jupiter system

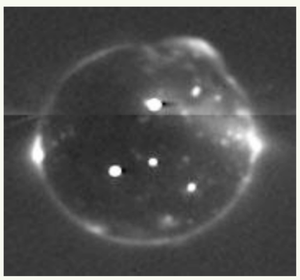




Key Spacecraft (S/C) Characteristics:

- High heritage, compact, redundant, low-power S/C design with 3-axis operation and compatibility with standard launch vehicle and 4-m fairing
- NASA-developed Roll Out Solar Arrays (ROSA) yield robust power margins though all nine Io encounters
- Radiation tolerance from rad-hard parts and shielding of sensitive electronics
- 2.1-m high-gain antenna (HGA) and redundant 25-W travelling wave tube amplifiers (TWTAs) provide >10 kbps/s to 34-m DSN in X band
- Bi-propellant system used for maneuvers; 3-axis attitude control
- Limited deployables (solar arrays, mag boom, and NAC cover)
- Low-power avionics combined with RAD750 processor
- 716 kg dry mass (49% total margin), 1551 kg wet mass (17% launch vehicle margin) and ≥44% total power margin in all modes
- Deep Space Optical Communication (DSOC) demonstration over a wide range of distances during cruise to Jupiter
- New technology limited to DSOC and some instrument components; technology infusion of advanced solar arrays

Culann Patera (from *Galileo*)



Io in eclipse (from *New Horizons*)