Outer Planets Assessment Group
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NASA Planetary Protection: Organizational Change and Tecnical Challenges

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Artist rendering of conceptual design for a potential future mission to land a robotic probe on the surface of Jupiter's moon Europa. NASA/JPL-Caltech

Reorganization of NASA Planetary Protection

- Agency Program Management Council (APMC) decision in May 2017.
- Planetary Protection Office moved from Science Mission Directorate to Office of Safety and Mission Assurance.
- Lisa Pratt started as Planetary Protection Officer in February 2018.
- Update planetary protection policies, requirements, and technical standards in response to science discoveries and changing federal legislation.
- Focus on early lifecycle implementation of clear and relevant mission requirements.
- Demonstrate collaborative relationship with mission engineers.

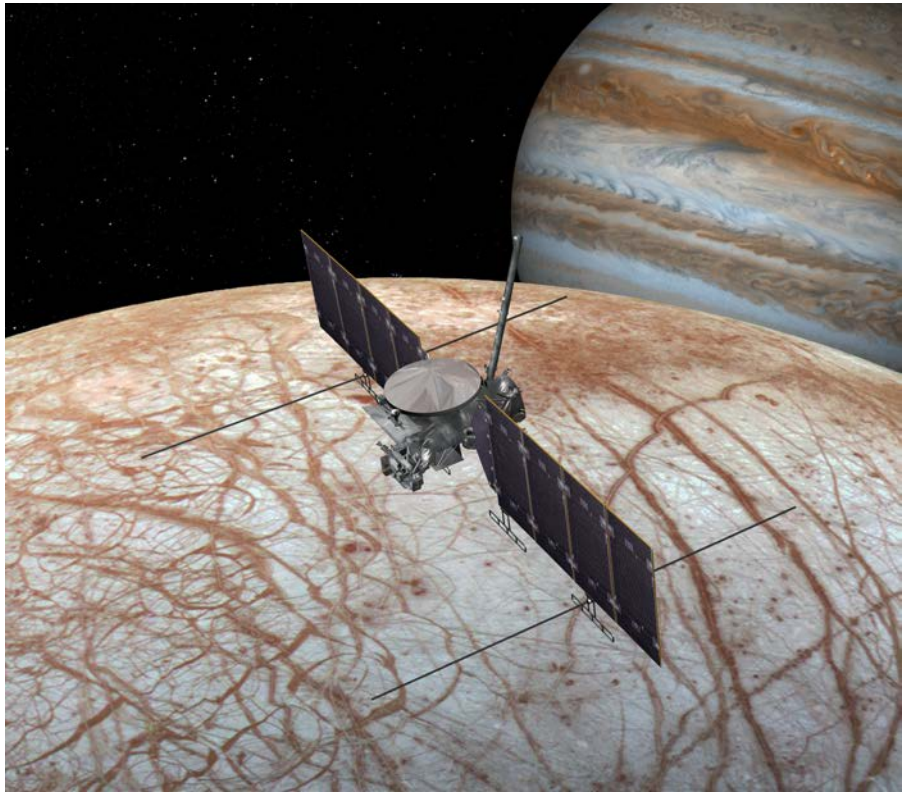
Juno spacecraft being lowered onto a fueling stand at Astrotech's Hazardous Processing Facility in Titusville, Florida in June 2011.

Planetary protection requirements ensure *valid* and *safe* scientific exploration for extraterrestrial life

NASA Objectives during robotic missions beyond Earth:

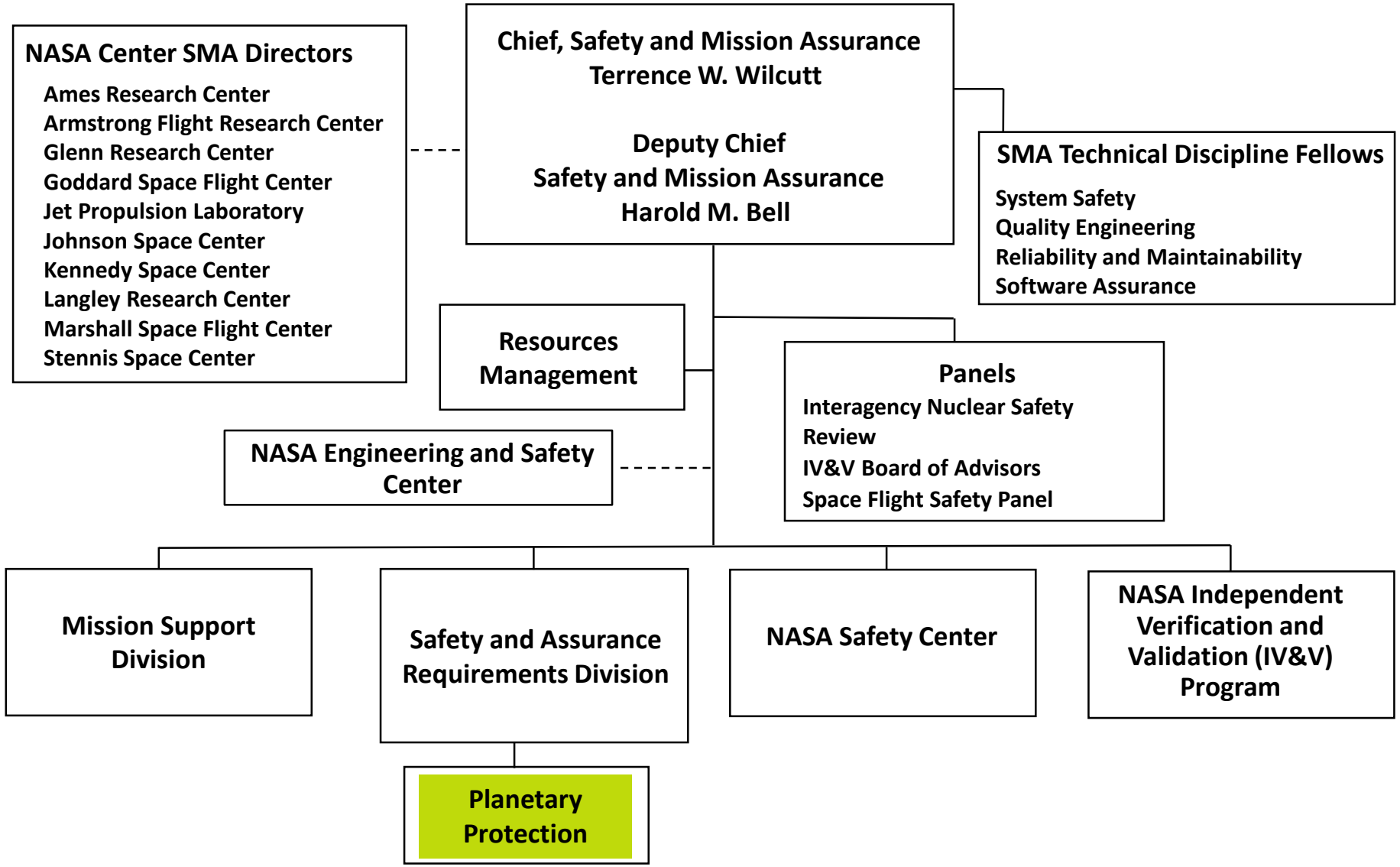
•(*valid*) Avoid forward contamination of other worlds by terrestrial organisms carried on spacecraft.

•(*safe)* Prevent backward contamination of Earth by extraterrestrial life or bioactive molecules in samples returned for scientific study.



Artist vision of the Clipper spacecraft orbiting Europa

Office of Safety and Mission Assurance (OSMA)



Enduring Authority of the Outer Space Treaty

The Outer Space Treaty of 1967:

- Proposed to the UN in 1966
- Signed at Washington, London, Moscow on January 27, 1967
- Entered into force October 10, 1967

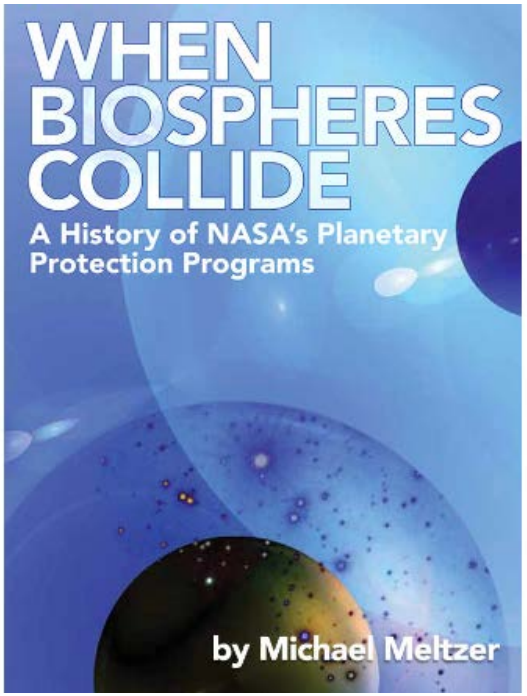
Article IX. States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose.

Article VI. States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty.

https://www.state.gov/t/isn/5181.htm

Over 50 Years of International Effort

- 1956, Rome: International Astronautical Federation meets to discuss lunar and planetary contamination
- Feb. 1958: International Council for Science (ICSU) forms committee on Contamination by ExtraTerrestrial Exploration
- June 1958: US National Academy Science establishes Space Studies Board (SSB)
- July 1958: Formation of NASA
- July 1958: Formation of UN committee on peaceful uses of outer space (COPUOS)
- Oct. 1958: Formation of Committee on Space Research (COSPAR) by ICSU
- 1959-1962: Publication of guidelines: US/USSR/COSPAR
- 1963: NASA acquires the first Planetary Quarantine Officer on loan from the Public Health Service



Relationship to COSPAR

NASA recognizes that only the 1967 Outer Space Treaty (OST) sets forth legal planetary protection requirements. It is however NASA policy to follow the Committee on Space Research (COSPAR) Planetary Protection Policy of 2017 ("COSPAR Planetary Protection Policy"), as amended. In carrying out this policy, NASA is guided by advice and recommendations by the National Academies of Sciences, Engineering, and Medicine as well as other independent advisory panels.

Expanding the knowledge frontier of space for the benefit of humankind

New Administration Direction

National Space Council

- Transform launch and re-entry licensing regime
- Consolidate space commerce responsibilities (except launch/reentry)
- Ensure protection and stewardship of radio frequency spectrum
- Review export licensing regulations
- Ensure a stable and orderly space environment

Space Policy Directives (SPD)

- SPD-1 Return to the Moon (and enable human exploration of Mars)
- SPD-2 Streamlining Regulations on Commercial use of Space
- SPD-3 National Space Traffic Management Policy

Congress debating space commerce

- House Resolution 2809, American Space Commerce Free Enterprise Act
- Received in Senate and referred to Commerce, Science, and Transportation

New NASA Advisory Committee on Regulatory and Policy Matters

- Chair Mike Gold

Planetary Protection Mission Categories (NASA/ESA/COSPAR Policy)

Types of Planetary Bodies	Mission Type	Misson Category
Not of direct interest for understanding the process of chemical evolution. No protection of such planets is warranted.	Any	I
Of significant interest relative to the process of chemical evolution, but only a remote chance that contamination by spacecraft could jeopardize future exploration. Documentation is required.	Any	II
Of significant interest relative to the process of chemical evolution, and/or the origin of life or for which scientific opinion provides a significant chance of contamination which could jeopardize a future biological experiment. Substantial documentation and mitigation is required.	Flyby, Orbiter *Mars, Europa, Enceladus*	III
See above	Lander, Probe *Mars, Europa, Enceladus*	IV *IVa, IVb, Ivc Mars*
Any solar system body. Unrestricted applies only to bodies deemed by scientific opinion to have no indigenous life forms.	Earth Return *Restricted or Unrestricted*	V

Categorization for Current New Frontiers Missions

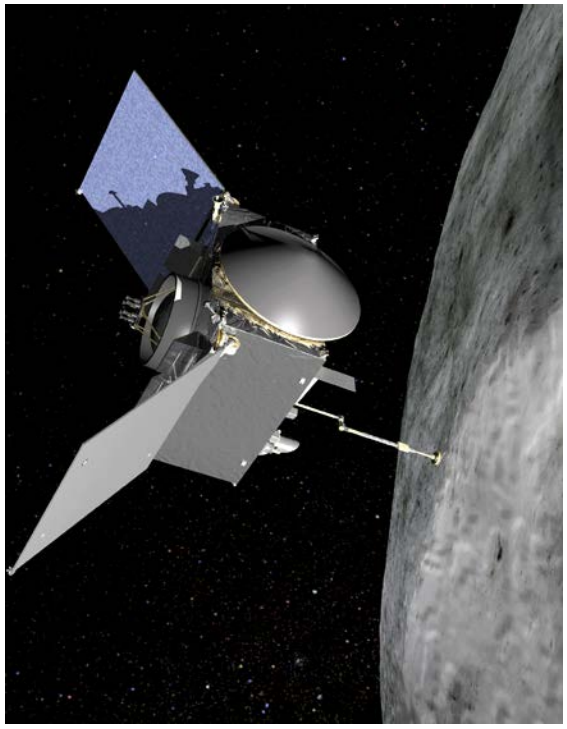
New Horizons
Pluto-Kuiper Belt
Category II

January 2006 Launch
Flyby Pluto July 2015
Kuiper image August 2018

JUNO
Jupiter Polar Orbiter
Category III

August 2011 Launch
Arrival Jupiter July 2016
13th flyby July 2018

OSIRIS-REx
Asteroid Sample Return
Category V Unrestricted



September 2016 Launch
Final approach Bennu 2018

Planetary Protection Provisions for Robotic Extraterrestrial Missions

NPR 8020.12D
Effective Date: April 20, 2011
Expiration Date: December 20, 2018

5.1		Numerical Implementation Limits for Forward Contamination Calculations not Otherwise Specified
	5.1.1	To the degree that numerical limits are required to support the overall policy objectives of this document, and except where numerical requirements are otherwise specified, the limit to be used is that the probability that a planetary body will be contaminated during the period of biological exploration shall be no more than 1x10-3. No specific format for probability of contamination calculations is specified.
	5.1.2	The period of biological exploration shall extend at least 50 years after a PP Category III or IV mission arrives at its protected target and no longer than the time point after which no organisms remain viable on the spacecraft.
	5.1.3	For all launch vehicle elements leaving Earth's orbit, the probability of impacting Mars shall be less than 1x10-4 for a period of 50 years. The probability of impact assessment should be provided in the Planetary Protection Plan.
	5.1.4	For all spacecraft crossing Mars orbit en route to other targets, the probability of impacting Mars shall be less than 1x10-2 for a period of 50 years. The probability of impact assessment should be provided in the Planetary Protection Plan.
	5.1.5	In the context of missions to icy satellites, "contamination" is defined as the introduction of a single viable terrestrial microorganism into a liquid-water environment.

Cleanroom Garments and Sample Acquisition

Garment Zones

Booties, hairnet and mask followed by hood, bunny, suit, boots, gloves and wrist tape.

Polyester Wipes

Spacecraft hardware and transfer surfaces are sampled by wiping or swabbing.

Extraction of Microbes

Polyester wipe inserted into sterile glass bottle with deionized water for extraction.

Standard Spore Assay

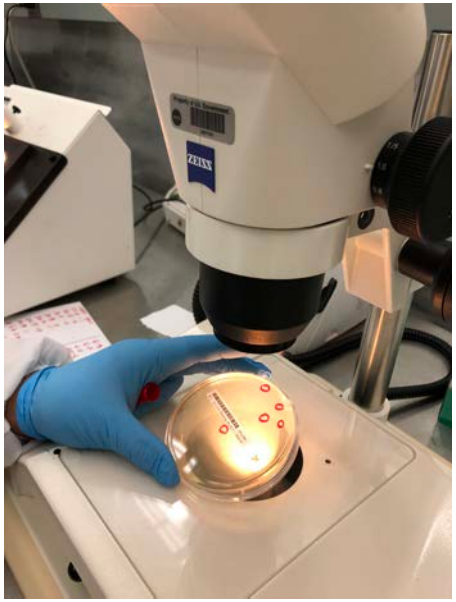
Sterilization of glassware and growth media in autoclave

Heat shock of the extracted samples at 80°C for 15 minutes

Quenching shocked samples in ice bath

Quantitative aliquots plated on Trypticase Soy Agar

Visual enumeration of colony forming units after incubation at 32˚C for 24, 48, and 72 hours



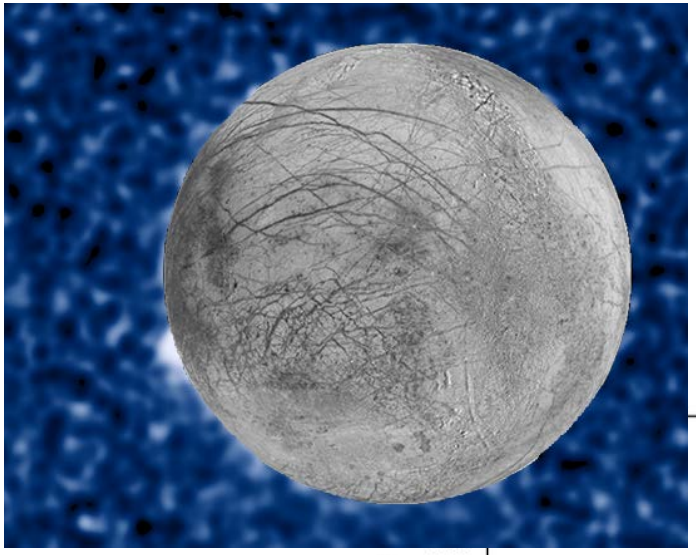
Bar coding enables reliable tracking of bioburden data

Returning Samples to Earth

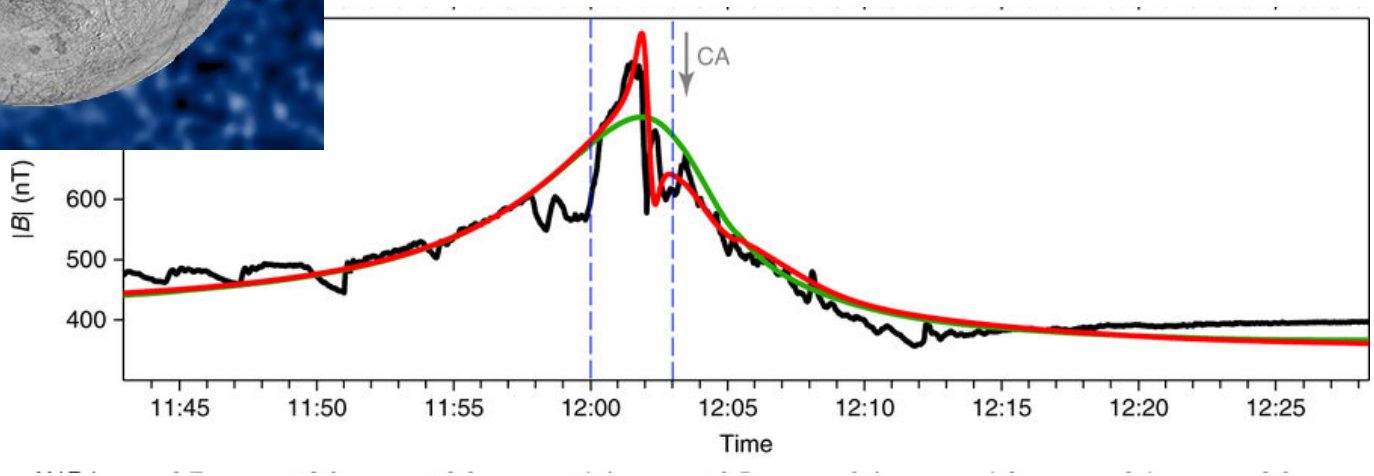
Mission Category	Implementation Requirements	Examples
V Earth Return Unrestricted	• As appropriate for the specified category of the outbound mission. No inbound PP requirements.	Moon,Venus, Comets Some Asteroids
V Earth Return Restricted	• Unrestricted requirement plus the following. • Inbound requirements for impact avoidance and contamination control: clean room assembly, microbial containment of sample, break chain of contact with target body, and sample containment. • On-Earth requirements for biohazard testing in receiving laboratory, monitoring of project activities, and supporting studies and research as needed for implementation.	Mars, Europa, Enceladus Others to be determined e.g., Phobos, Titan, Ganymede

minor rewording from https://planetaryprotection.nasa.gov/

Discoveries Impact Planetary Protection



NASA/ESA Hubble composite image showing a suspected plume of material erupting and rising ~200 km above Europa in 2017.



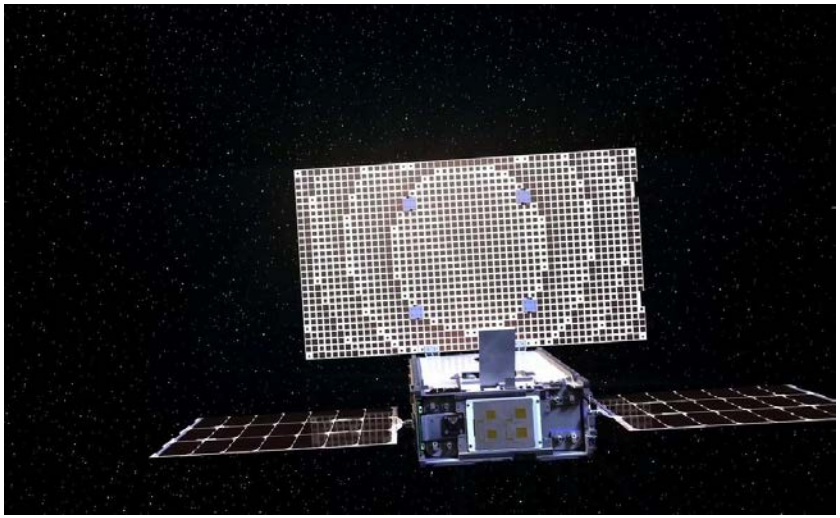
Galileo data from 1997 was reexamined and showed short time-scale fluctuations indicating passage through a plume of similar scale to Hubble images.

Black = magnetic data, Green = model no plume, Red = model with plume.

Jia et al. 2018, *Nature Astronomy*

Proliferation of Secondary Payloads

- Expanding exploration by addition of cubesats, small satellites, and ThinSats as secondary payloads on NASA science and human exploration missions.
- Cubesat assembly and launch will comply with NASA planetary protection requirements.



- First launch of planetary cubesats in May 2018 was on rocket carrying InSight to Mars as a technology demonstration for communication during entry, descent, and landing.