



Inventory of Planetary Protection Resources

By

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2019 STAR SETI Intern



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United Nations Outer Space Treaty

Article IX

In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. 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. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, may request consultation concerning the activity or experiment.



UNITED NATIONS
New York, 2002

<http://www.unoosa.org/pdf/publications/STSPACE11E.pdf>

COSPAR Policies

COSPAR, Referring to COSPAR Resolutions 26.5 and 26.7 of 1964, the Report of the Consultative Group on Potentially Harmful Effects of Space Experiments of 1966, the Report of the same Group of 1967, and the Report of the COSPAR/IAU Workshop of 2002, notes with appreciation and interest the extensive work done by the Panel on Standards for Space probe Sterilization and its successors the Panel on Planetary Quarantine and the Panel on Planetary Protection and accepts that for certain space mission/target body combinations, controls on contamination shall be imposed in accordance with a specified range of requirements, based on the following policy statement:

Although the existence of life elsewhere in the solar system may be unlikely, the conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized. In addition, the Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from another planet. Therefore, for certain space mission/target planet combinations, controls on contamination shall be imposed, in accordance with issuances implementing this policy. (DeVincenzi et al. 1983).



<http://w.astro.berkeley.edu/~kalas/ethics/documents/environment/COSPAR%20Planetary%20Protection%20Policy.pdf>

Office of Planetary Protection

Mission Categories

Types of Planetary Bodies	Mission Type ¹	Mission Category ²
Bodies “not of direct interest for understanding the process of chemical evolution or the origin of life.”	Any	I
Bodies of “significant interest relative to the process of chemical evolution and the origin of life, but where there is only a remote chance that contamination carried by a spacecraft could compromise future investigations.”	Any	II & II*
Bodies of significant interest to the process of “chemical evolution and/or the origin of life”, and where “scientific opinion provides a significant chance that contamination could compromise future investigations.”	Flyby, Orbiter	III
	Lander, Probe	IV ³
Earth-return missions from bodies “deemed by scientific opinion to have no indigenous life forms.”	unrestricted Earth-Return	V (unrestricted)
Earth-return missions from bodies deemed by scientific opinion to be of significant interest to the process of chemical evolution and/or the origin of life.	restricted Earth-Return	V (restricted)
¹ If gravity assist is utilized during a flyby, constraints for the planetary body with the highest degree of protection may be required. ² For missions that target or encounter multiple planets, more than one PP category may be specified. ³ Category IV missions for Mars are subdivided into IVa, IVb, and IVc.		

<https://planetaryprotection.nasa.gov/categories>

Office of Planetary Protection

Solar System Missions

Category	Planetary Body	Mission	Mission Status
II	Asteroid Eros	<u>NEAR-Shoemaker</u>	Completed
II	Comets Tempel 1 & Hartley 2	<u>Deep Impact/EPOXI</u>	Ongoing
II	Comets Encke, Schwassmann-Wachmann-3 and d'Arrest.	<u>CONTOUR</u>	Failed
II	Jupiter	<u>Galileo</u>	Completed
II	Jupiter	<u>Juno</u>	Ongoing
II	Jupiter/Saturn	<u>Pioneer 10&11</u>	Completed
II	Jupiter/Saturn/Heliosheath	<u>Voyager</u>	Ongoing
II	Mercury (Venus fly-by)	<u>MESSENGER</u>	Completed
II	Moon	<u>Chandrayaan-1/ISRO (M3)</u>	Completed
II ¹	Moon	<u>Chang'e-3/CNSA</u>	Ongoing
II	Moon	<u>Clementine</u>	Completed
II	Moon	<u>Grail</u>	Completed
II	Moon	<u>LADEE</u>	Completed
II	Moon	<u>Lunar Prospector</u>	Completed
II	Moon	<u>Lunar Reconnaissance Orbiter</u>	Ongoing
II	Moon	<u>Ranger 1-9</u>	Completed
II	Moon	<u>Surveyor</u>	Completed
II	Pluto/Charon	<u>New Horizons</u>	Ongoing

II	Saturn	<u>Cassini-Huygens</u>	Completed
II	Sun	<u>Solar Orbiter Collaboration</u>	Planning Phase
	Sun	<u>Ulysses</u>	Completed
II	Venus	<u>Magellan</u>	Completed
II	Venus	<u>Pioneer-Venus</u>	Completed
III (II-comet)	Comet Borrelly	<u>Deep Space 1</u>	Completed
III (II-comet)	Comet C-G, Asteroid Lutetia	<u>Rosetta</u>	Ongoing
III (TGO), IVa (EDM)	Mars	<u>ExoMars 2016/ESA: Trace Gas Orbiter (TGO) & Entry, Descent, and Landing Demonstrator Module (EDM)</u>	Ongoing
III	Asteroids Vesta & Ceres (Mars flyby)	<u>Dawn</u>	Ongoing
III	Europa	<u>Europa Clipper</u>	Planning Phase
III ¹	Mars	<u>Mars Orbiter Mission (Mangalyaan)/ISRO</u>	Ongoing
III	Mars	<u>Mars Climate Orbiter</u>	Failed
III	Mars	<u>Mars Express/ESA (ASPERA-3)</u>	Ongoing
III	Mars	<u>Mars Global Surveyor</u>	Completed
III	Mars	<u>Mars Observer</u>	Failed
III	Mars	<u>Mars Odyssey</u>	Ongoing
III ¹	Mars	<u>Mars Orbiter Mission/ISRO</u>	Ongoing
III	Mars	<u>Mars Reconnaissance Orbiter</u>	Ongoing
III	Mars	<u>MAVEN</u>	Ongoing

III	Mars	<u>Viking 1-2 Orbiters</u>	Completed
III	Mercury, Venus, Mars	<u>Mariner Missions</u>	Completed
IVa	Mars	<u>Deep Space 2</u>	Failed
IVa	Mars	<u>InSight</u>	Ongoing
IVa	Mars	<u>Mars Pathfinder</u>	Completed
IVa	Mars	<u>Mars Polar Lander</u>	Failed
IVa	Mars	<u>Mars Science Laboratory</u>	Ongoing
IVa	Mars	<u>MER Opportunity</u>	Ongoing
IVa	Mars	<u>MER Spirit</u>	Completed
IVb	Mars	<u>ExoMars 2020/ESA</u>	Planning Phase
IVb	Mars	<u>Viking 1-2 Landers</u>	Completed
IVc	Mars	<u>Mars Phoenix Lander</u>	Completed
V (restricted)	Moon	<u>Apollo 11, 12, 14</u>	Completed
V (restricted)	Mars	<u>Mars 2020</u>	Planning Phase
V (unrestricted)	Asteroid 25143 Itokawa	<u>Hayabusa/JAXA</u>	Completed
V (unrestricted)	Asteroid 1999 JU3	<u>Hayabusa 2/JAXA</u>	Ongoing
V (unrestricted)	Asteroid 1999 RQ36	<u>OSIRIS-REx</u>	Ongoing
V (unrestricted)	Comets Wild 2 & Tempel 1	<u>Stardust NExT</u>	Completed
V (unrestricted)	Heliosphere	<u>Genesis</u>	Completed
V (unrestricted)	Moon	<u>Apollo 15-17</u>	Completed

<https://planetaryprotection.nasa.gov/missions>

Former or current NASA Planetary Protection Officers

- Lawrence B. Hall 1963–1976 Planetary Quarantine Officer
- Richard S. Young* 1976–1979 PQO
- Donald L. DeVincenzi* 1979–1986 PQO/PPO (Changed 1981)
- John D. Rummel* 1986–1993 PPO
1997–2006
- Michael A. Meyer* 1993–1997 PPO
- Catharine A. Conley 2006–2018 PPO
- Lisa M. Pratt 2018–Present PPO *Also Exobiology/Astrobiology

Documentation and mission COSPAR status update

Pericles D. Stabekis

Genex Systems

April 23, 2013

Slideshow can be found using the following link:

https://docs.google.com/presentation/d/0Bx_LJbWBrLBLMVp4MDN6MjVTdGFFU3JtTlM0c1J3RXYtM1pJ/edit#slide=id.p2

Solar System Mission Image and Planetary Protection

detail Slideshow



Mars Global Surveyor

Mission Type:

Orbiter

Planetary Protection Category:

III

Orbit Insertion: September 12, 1997

End of Mission: November 14, 2006

Mars Global Surveyor: Planetary Protection Category III

"Mars orbiters such as MGS... are classified Category III and subject to biological burden limits or orbital lifetime requirements to ensure against inadvertent contamination of the planet in the event of a crash..."

...Planetary protection requirements for MGS and Mars Odyssey are intended to ensure that the orbiting spacecraft do not inadvertently drop out of orbit and crash onto Mars after their missions are completed. Planetary protection requirements for the Mars Exploration Rovers are intended to ensure that these landers did not transport Earth microbes to the surface of Mars."

<https://planetaryprotection.nasa.gov/about-categories/>

Artist concept of Mars Global Surveyor over Mars



The Mars Global Surveyor orbiter was designed to study the composition of Mars.

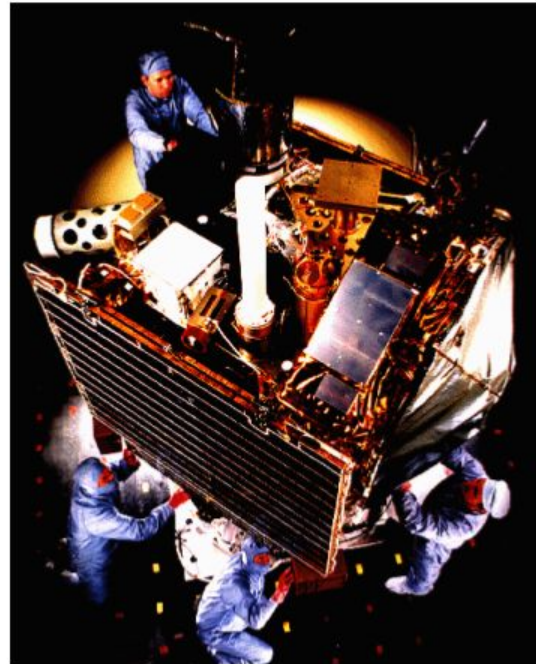
https://photojournal.jpl.nasa.gov/jpegMod/PIA17486_mod_est.jpg

Mars Global Surveyor: Planetary Protection Category III (Flyby, Orbiter)

The planet Mars is of... “significant interest relative to the process of chemical evolution and/or the origin of life and for which scientific opinion provides a significant chance that contamination by spacecraft could compromise future investigations.” Therefore, this mission followed category III instructions to implement “...impact avoidance and/or contamination control including: cleanroom assembly, microbial reduction, and trajectory biasing.”

https://nodis3.gsfc.nasa.gov/npg_img/N_PR_8020_012D_/N_PR_8020_012D_.pdf

MGS in a Cleanroom



<https://mgs-mager.gsfc.nasa.gov/overview/mgsincleanrm.html>

Mars Global Surveyor: Planetary Protection Category III

“MGS used aerobraking to achieve its mapping orbit. Through its extended mission, MGS has complied with the PP orbital lifetime requirement for 20 and 50 years after launch. This holds true for the current orbit of about 380 kms.

The spacecraft was assembled in a class 100K clean room and its surface cleanliness maintained through wiping with isopropyl alcohol.”

https://docs.google.com/presentation/d/0Bx_UbWBrLBLMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



More photos can be found
in the link(s) below

1. Spacecraft
 - a. https://mars.jpl.nasa.gov/mgs/movpics/atlo_pics/launch/launch.html
2. Films
 - a. <https://mars.nasa.gov/mgs/gallery/videos.html#mgsorbits2005-11-23>





Phoenix Mars Lander

Mission Type:

Lander

Planetary Protection Category:

IVc

Landing: May 25, 2008

End of Mission: November 2, 2008

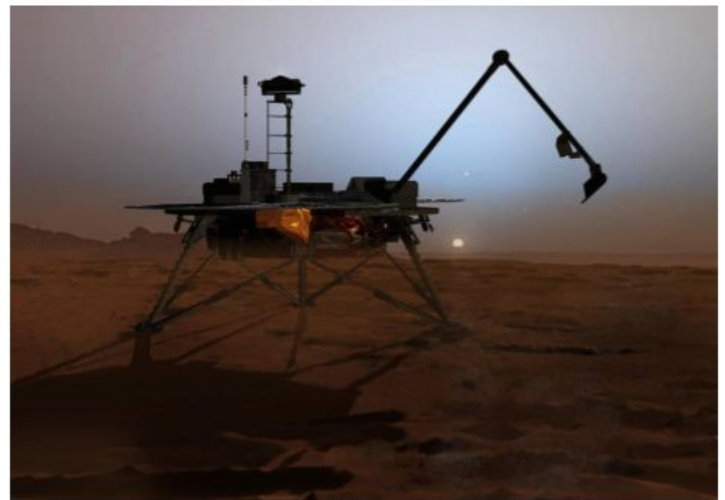
Phoenix Mars Lander Planetary Protection Category IVc

The Phoenix Mars Lander falls under category IVc in which the spacecraft "...planned to target a body of chemical evolution or **origin-of-life interest**... Requirements include rather detailed documentation... *bioassays to enumerate the burden, a probability of contamination analysis, an inventory of the bulk constituent organics, and an increased number of implementing procedures.* The latter may include trajectory biasing, the use of clean rooms (Class 100,000 or better) during spacecraft assembly and testing, bioload reduction, possible partial sterilization of the hardware having direct contact with the target body, and a bioshield for that hardware, and, in rare cases, a complete sterilization of the entire spacecraft.

Subdivisions of Category IV (designated IVa, IVb, or IVc) address lander and rover missions to Mars (with or without life detection experiments), and **missions landing or accessing regions on Mars which are of particularly high biological interest**"

<https://planetaryprotection.nasa.gov/about-categories/>

Artist rendition of the Phoenix Mars Lander on the Red Planet



The Phoenix lander used a robotic arm to access ice under Martian polar caps.

https://www.nasa.gov/mission_pages/phoenix/images/index.html

Phoenix Mars Lander
Planetary Protection
Category IV subdivision for Mars
Lander, Probe

The planet Mars is of... “significant interest relative to the process of chemical evolution and/or the origin of life and for which scientific opinion provides a significant chance that contamination by spacecraft could compromise future investigations.” Therefore, missions investigating Martian Special Regions such as the Mars Phoenix Lander, “even if they do not include life detection experiments they are included in Category IV. Martian Special Regions include those within which terrestrial organisms are likely to replicate and those potentially harboring extant Martian Life.”

<https://planetaryprotection.nasa.gov/categories>

Artist concept of Mars Global Surveyor over Mars



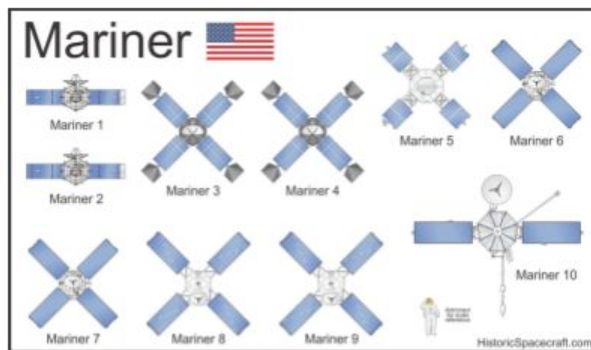
The Mars Global Surveyor orbiter was designed to study the composition of Mars.

https://photojournal.jpl.nasa.gov/jpegMod/PIA17486_mod_est.jpg

More photos can be found in the link(s) below

1. Phoenix Mars Lander
Factsheet:
 - a. http://phoenix.lpl.arizona.edu/pdf/fact_sheet.pdf
2. Mission Postcards
 - a. <http://phoenix.lpl.arizona.edu/postcards.php>
3. Article on Phoenix Spacecraft
 - a. <https://www.space.com/42947-phoenix-mars-lander.html>





Mariner 3,4,6,7,8,9

Mission Type:

Lander

Planetary Protection Category:

IVc

Started: May 1960

Completed: March 24, 1975

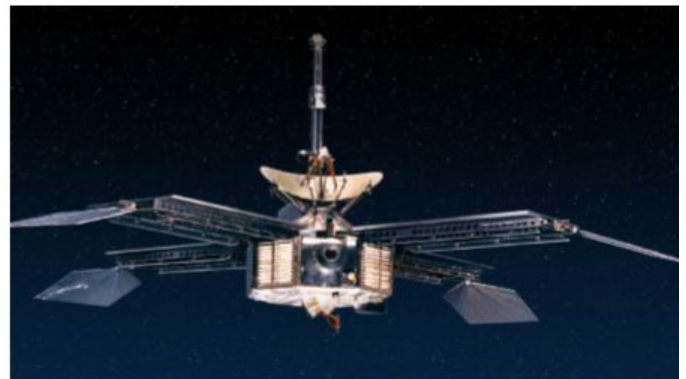
Mariner 3

Planetary Protection Category III

"Mariner 3 was a 260 kg solar-cell and battery-powered spacecraft designed to make scientific measurements in the vicinity of Mars and to obtain photographs of the planet's surface and transmit these to Earth. It was intended that the spacecraft would encounter Mars after a 325-million mile journey in a little less than 8 months. A protective shield failed to eject after the spacecraft had passed through the atmosphere. None of the instrument sensors were uncovered, and the added weight prevented the spacecraft from attaining its prescribed Mars trajectory.

The spacecraft was assembled in a class 100K cleanroom and its surface cleanliness maintained through wiping with isopropyl alcohol. The surface microbial burden was 2×10^5 spores (est.)."

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVTdGFFU3JlTIM0c1J3RXYtM1pJ/edit#slide=id.p1



Mariner 4

Planetary Protection Category III

"Mariner 4 was the first spacecraft to get a close look at Mars. Flying as close as 9,846 kilometers (6,118 miles), Mariner 4 revealed Mars to have a cratered, rust-colored surface, with signs on some parts of the planet that liquid water had once etched its way into the soil. In addition to various field and particle sensors and detectors, the spacecraft had a television camera, which took 22 television pictures covering about 1% of the planet. Initially stored on a 4-track tape recorder, these pictures took four days to transmit to Earth.

The spacecraft was assembled in a class 100K clean room and its surface cleanliness maintained through wiping with isopropyl alcohol.

The surface microbial burden was 2×10^5 spores (est.)."

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



https://www.nasa.gov/sites/default/files/1964_november_mariner_04_0.jpg

Mariner 6 & 7

Planetary Protection Category III

"Mariners 6 and 7 were identical twins in a two-spacecraft mission to Mars. Launched 31 days apart on Atlas/Centaur rockets, the spacecraft arrived at their closest approach to Mars (3,430 kilometers, or 2,130 miles) just four days apart. They **transmitted to Earth a total of 143 pictures of Mars** as they approached the planet and 55 close-up pictures as they flew past the equator and southern hemisphere...

The **spacecraft also studied the atmosphere and its chemical composition**. The spacecraft was assembled in a class 100K clean room and its surface cleanliness maintained through wiping with isopropyl alcohol.

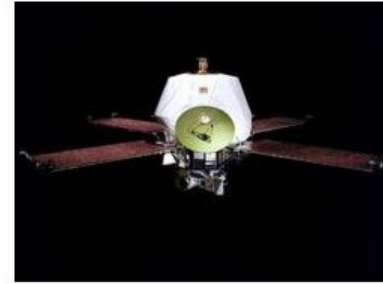
The surface microbial burden was 2.44×10^4 spores for Mariner 6 and 3×10^5 spores for Mariner 7 (both assayed)."

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



<https://nssdc.gsfc.nasa.gov/nmc/spacecraft/display.action?id=1969-014A>

Mariner 8 & 9
Planetary Protection Category III



“Mariner 8 was intended to go into Mars orbit and return images and data. It was launched on an Atlas-Centaur SLV-3C booster (AC-24) on May 8, 1971. The main Centaur engine was ignited 265 seconds after launch, but the upper stage began to oscillate in pitch and tumbled out of control. The Centaur stage shutdown 365 seconds after launch due to starvation caused by the tumbling. The Centaur and spacecraft payload separated and re-entered the Earth’s atmosphere approximately 1500 km downrange and **fell into the Atlantic Ocean about 560 km north of Puerto Rico.**

The spacecraft was assembled in a class 100K clean room and its surface cleanliness maintained through wiping with isopropyl alcohol. The surface microbial burden was 1.2×10^4 spores (assayed).

Mariner 9 is a Mars orbiter that was launched on May 30, 1971 and reached the planet on November 14 of the same year, becoming the first spacecraft to orbit another planet, narrowly beating Soviet Mars 2 and Mars 3, which both arrived within a month. After months of dust-storms it managed to send back clear pictures of the surface.

The spacecraft was assembled in a class 100K clean room and its surface cleanliness maintained through wiping with isopropyl alcohol. The surface microbial burden was 1.2×10^3 spores (assayed).

https://docs.google.com/presentation/d/0Bx_IJbWBrLBLMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



Stardust

Mission Type:

Comet Sample Return Mission

Planetary Protection Category:

V unrestricted

Launched on February 7, 1999

Stardust Mission Planetary Protection Category V unrestricted

Category V pertains to all missions for which the spacecraft, or a spacecraft component, returns to Earth. The concern for these missions is the protection of the Earth from back contamination resulting from the return of extraterrestrial samples (usually soil and rocks). **A subcategory called "Unrestricted Earth Return" is defined for solar system bodies deemed by scientific opinion to have no indigenous life forms. Missions in this subcategory have requirements on the outbound (Earth to target body) phase only, corresponding to the category of that phase (typically Category I or II).**

<https://planetaryprotection.nasa.gov/about-categories/>



The primary goal of Stardust is to collect dust and carbon-based samples during its closest encounter with Comet Wild 2 - pronounced "Vilt 2" after the name of its Swiss discoverer - is a rendezvous scheduled to take place in January 2004, after nearly four years of space travel.

Link to more cleanroom images from this mission

<https://stardust.jpl.nasa.gov/photo/cleanroom.html>

Stardust Mission Planetary Protection Category V unrestricted

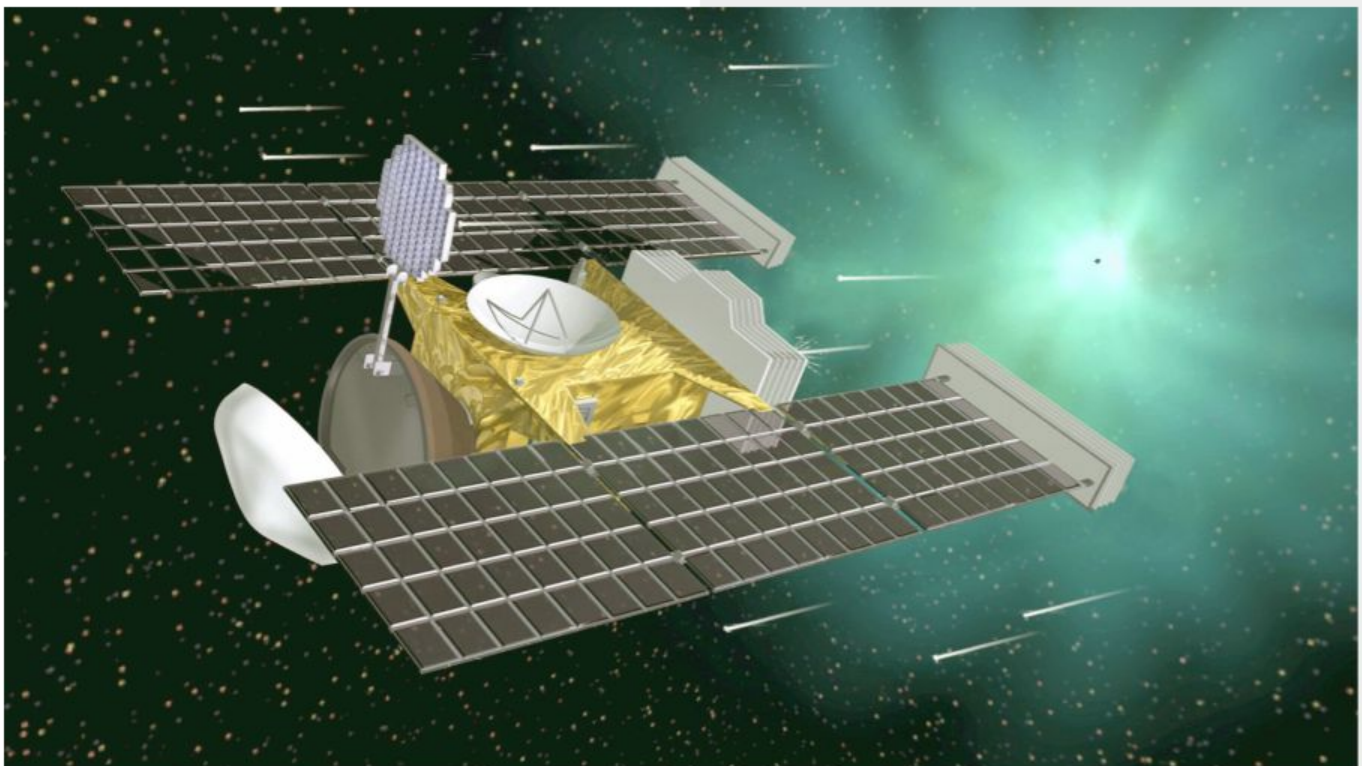
"Stardust was launched on February 7, 1999. Its primary mission was to collect dust samples from the coma of comet Wild 2, as well as samples of cosmic dust, and return these to Earth for analysis. It was the first sample return mission of its kind. En route to Comet Wild 2, the spacecraft also flew by and studied the asteroid 5535 Annefrank. The primary mission was successfully completed on January 15, 2006, when the sample return capsule returned to Earth.

Stardust was a PP Category V mission, deemed "Safe for Earth Return". There were no PP requirements levied to it."

https://docs.google.com/presentation/d/0Bx_IJbWBrl.BLMVp4MDN6MjVTdGFUFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1

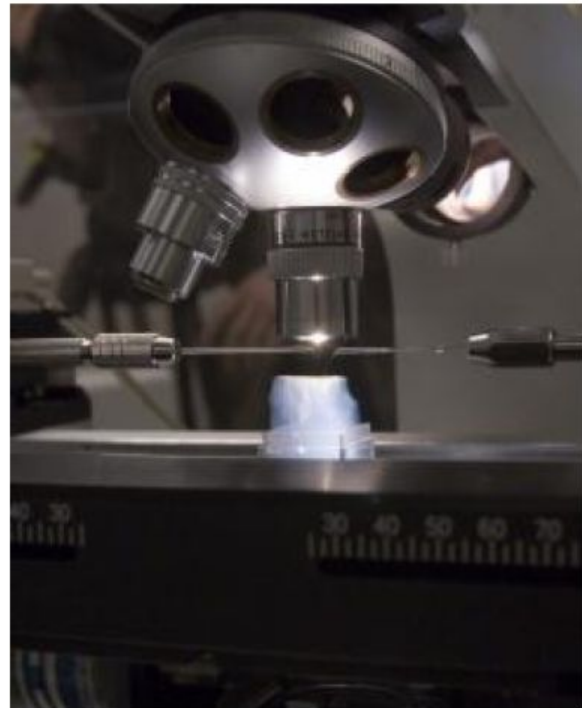


https://stardust.jpl.nasa.gov/photo/uttr_047.jpg



More Photos can be found
in the link(s) below

1. Comet images
 - a. <https://stardust.jpl.nasa.gov/news/news97.html>
2. Launch Images
 - a. <https://stardust.jpl.nasa.gov/photo/ksc990207.html>
3. Aerogel images
 - a. <https://stardust.jpl.nasa.gov/news/news108.html>





Deep Impact

Mission Type:

Fly By

Planetary Protection Category:

II

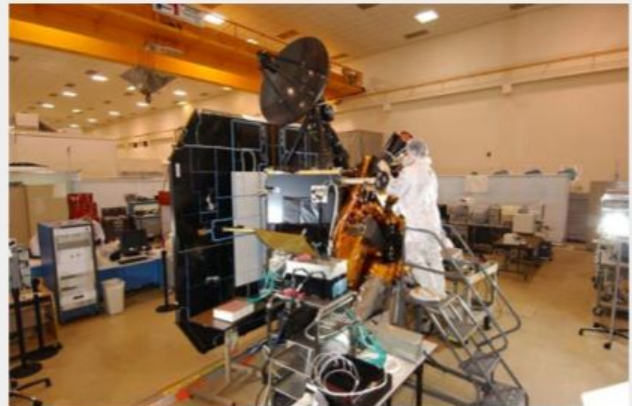
Launch date: January 12, 2005

Deep Impact Mission Planetary Protection Category II

"Category II includes all types of missions to those target bodies where there is significant interest relative to the process of chemical evolution and the origin of life, but where there is only a remote chance that contamination carried by a spacecraft could jeopardize future exploration."

The requirements are only for simple documentation. This documentation includes a short planetary protection plan is required for these missions, primarily to outline intended or potential impact targets; brief pre-launch and post-launch analyses detailing impact strategies; and a post-encounter and end-of-mission report providing the location of inadvertent impact, if such an event occurs."

<https://planetaryprotection.nasa.gov/about-categories/>



https://www.nasa.gov/mission_pages/deepimpact/multimedia/0701-assembly744d.html

Deep Impact Mission Planetary Protection Category II

“Deep Impact/ EPOXI is a PP Category II mission. The combined spacecraft and upper stage will not encounter any extra-terrestrial solar system bodies with the exception of the comet (targeted). However, the flyby spacecraft and the upper stage will enter heliocentric orbits that cross the orbit of Mars.”

https://docs.google.com/presentation/d/0Bx_IJbWBrlBLMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



https://www.nasa.gov/mission_pages/deepimpact/imagegallery/#lowerAccordion-set1-slide5

More Photos Can be found
using the link(s) below

1. Spacecraft Graphics
 - a. https://www.nasa.gov/mission_pages/deepimpact/spacecraft/index.html
2. Multimedia
 - a. https://www.nasa.gov/mission_pages/deepimpact/multimedia/index.html#.XTdJeZNKi0Q





Deep Space 1

Mission Type:

Flyby

Planetary Protection Category:

III

Oct. 24, 1998 – Dec. 18, 2001

Deep Space Planetary Protection Category III

“Category III includes certain types of missions to a target body of chemical evolution or origin-of-life interest, or for which scientific opinion holds that the mission would present a significant chance of contamination which could jeopardize future biological exploration.

Requirements consist of documentation (more involved than that for Category II) and some implementing procedures, including trajectory biasing, the use of clean rooms (Class 100,000 or better) during spacecraft assembly and testing, and possibly bioburden reduction. Although no impact is generally intended for Category III missions, an inventory of bulk constituent organics is required if the probability of inadvertent impact is significant.”

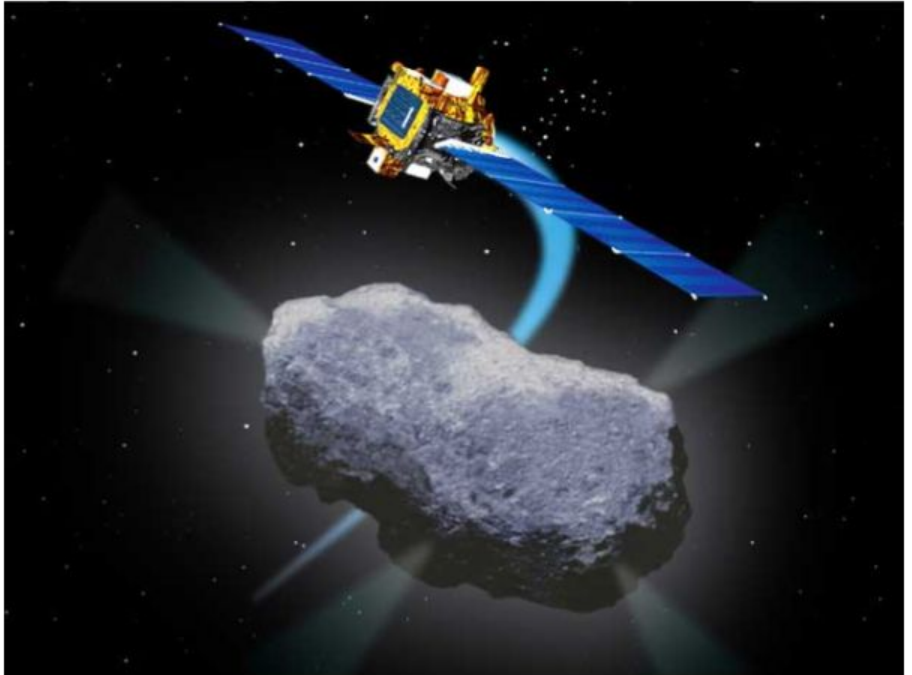
<https://planetaryprotection.nasa.gov/about-categories/>



<https://www.jpl.nasa.gov/nmp/ds1/img/98pc1178.gif>

More Photos can
be found in the
link(s) below

1. Artist Rendition Spacecraft
 - a. https://www.jpl.nasa.gov/missions/web/deep_space_1.jpg
 - b. https://www.jpl.nasa.gov/nmp/ds1/img/DS1_Borrelly_Land_browse.jpg





Galileo Mission

Mission Type:

Orbiter

Planetary Protection Category:

II

Launch date: October 18, 1989

Galileo Mission Planetary Protection Category II

“Category II includes all types of missions to those target bodies where there is significant interest relative to the process of chemical evolution and the origin of life, but where there is only a remote chance that contamination carried by a spacecraft could jeopardize future exploration.

The requirements are only for simple documentation. This documentation includes a short planetary protection plan is required for these missions, primarily to outline intended or potential impact targets; brief pre-launch and post-launch analyses detailing impact strategies; and a post-encounter and end-of-mission report providing the location of inadvertent impact, if such an event occurs.”

<https://planetaryprotection.nasa.gov/about-categories/>



<https://www.gettyimages.com.au/photos/galileo-1989?family=editorial&phrase=galileo%20-%201989&sort=best#license>

Galileo Mission Planetary Protection Category II

"The data Galileo collected supported the theory of liquid water under the icy surface of Europa, and there were indications of similar liquid-salt water layers under the surfaces of Ganymede and Callisto."

"For PP purposes, Galileo was classified category II mission, with only documentation requirements. It was agreed, however, that should the mission make discoveries that would warrant protection of any planetary body beyond the category II requirements, the decision on the spacecraft's eventual disposition would have to be negotiated with the NASA PP Officer."

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVtdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1

Galileo Mission Planetary Protection Category II

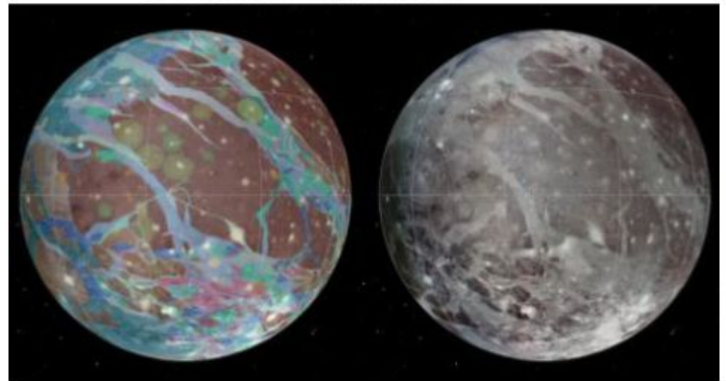
"Indeed, the discoveries of potential liquid water under the surfaces of Europa, Ganymede, and Callisto caused a decision to dispose the spacecraft by impacting Jupiter."

On September 21, 2003, after 14 years in space and 8 years in the Jovian system, Galileo's mission was terminated by sending the orbiter into Jupiter's atmosphere at a speed of over 48 kilometres (30 mi) per second, dramatically reducing the chance of contaminating local moons with terrestrial microorganisms.

For the record, the probability of impacting Venus during gravity assist flybys was 1×10^{-10} ."

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVtdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1

Ganymede Global Geologic Map
and Global Image Mosaic



<https://photojournal.jpl.nasa.gov/mission/Galileo>

Bright scars on a darker surface testify to a long history of impacts on Jupiter's moon Callisto in this image of Callisto from NASA's Galileo spacecraft.

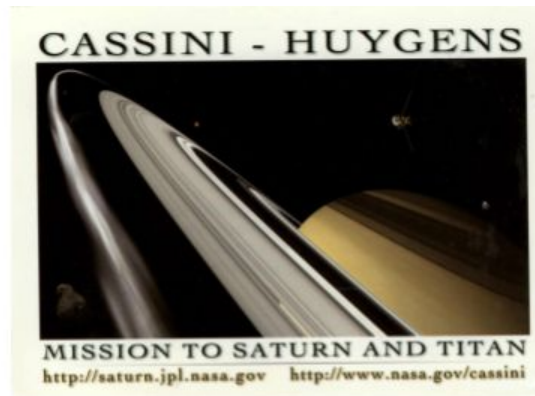


https://solarsystem.nasa.gov/resources/811/global-callisto-in-color/?category=missions_galileo

More photos can be found
using the link(s) below

1. Artist rendition of spacecraft.
 - a. https://docs.google.com/presentation/d/13P6tan_pAMy5hmTwRPmp4HxPyFCw0S9W910HI8Hqxu4/edit#slide=id.g5c1694cfae_0_183
2. Galileo in space
 - a. <https://www.nasa.gov/directorates/heo/scan/images/history/October1989.html>
3. Launch
 - a. <https://photojournal.jpl.nasa.gov/jpeg/PIA00726.jpg>
4. Spacecraft
 - a. <https://i.pinimg.com/originals/e6/16/b6/e616b66e9892d024a4c399c1681b803d.jpg>





Cassini-Huygens

Mission Type:

Orbiter, Flyby

Planetary Protection Category:

II

Dates: Oct 15, 1997 - Sep 15, 2017

Cassini-Huygens Mission Planetary Protection Category II

"Cassini was classified PP Category II mission. In addition to documentation requirements, there were probability of impact limits for several of the planetary bodies that were/will be encountered."

<https://mail.google.com/mail/u/0/#search/mracemom%40aol.com/FMfcgxwChcqWDITMNIgPSCtZPcHXklkB?projector=1&messagePartId=0.1>

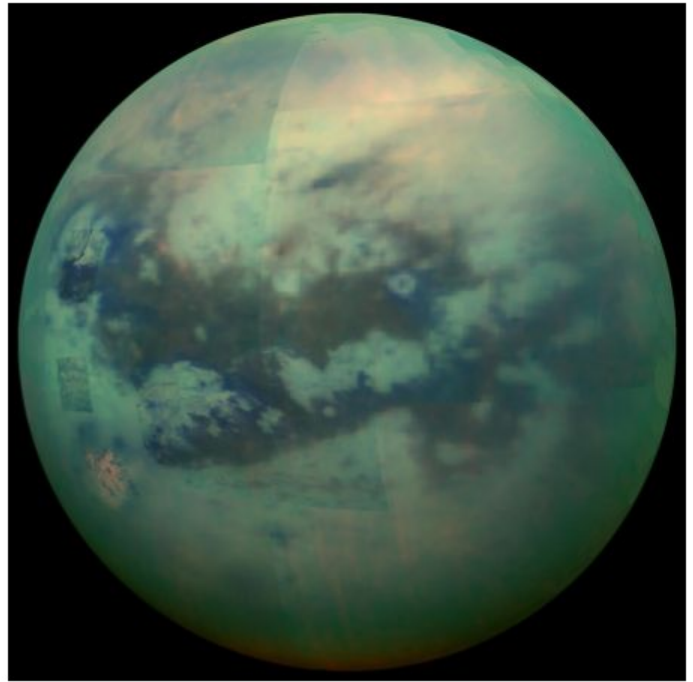


https://docs.google.com/presentation/d/13P6tan_pAMy5hmTwRPmp4HxPyECW0S9W910Hl8hqxu4/edit#slide=id.g5c3e780d6f_0_97

Cassini-Huygens Mission Planetary Protection Category II

“After 20 years in space — 13 of those years exploring Saturn — Cassini exhausted its fuel supply. And so, to protect moons of Saturn that could have conditions suitable for life, Cassini was sent on a daring final mission that would seal its fate. After a series of nearly two dozen nail-biting dives between the planet and its icy rings, Cassini plunged into Saturn’s atmosphere on Sept. 15, 2017, returning science data to the very end.”

<https://solarsystem.nasa.gov/missions/cassini/overview/>



https://solarsystem.nasa.gov/missions/cassini/galleries/images/?page=0&per_page=25&order=created_at+desc&search=&tags=cassini&condition_1=1%3Ais_in_resource_list&category=51

More photos can be found using the link(s) below

1. Artist Rendition of Spacecraft orbiting Saturn
 - a. <https://www.jpl.nasa.gov/missions/web/cassini.jpg>
2. Spacecraft
 - a. <https://media.gettyimages.com/photos/-picture-id607403926?s=2048x2048>
 - b. <https://www.gettyimages.com/photos/ends-cassini-spacecraft-mission?mediatype=photography&phrase=ends%20cassini%20spacecraft%20mission&sort=mostpopular>



<https://solarsystem.nasa.gov/missions/cassini/mission/grand-finale/overview/>



Mars Odyssey

Mission Type:

Orbiter

Planetary Protection Category:

III

Mission Status Currently Operating

Mars Orbit Insertion October 24, 2001

Launched April 7, 2001

Mars Odyssey Planetary Protection Category III

"Mars Odyssey probability of impact estimates before launch were 9.1×10^{-3} for L+20 yrs, and 5.9×10^{-2} for L+20 to L+50 yrs. The latter exceeded the required 5×10^{-2} value and a raise maneuver was planned at the end of the mission to comply.

In the course of the extended missions, the project proposed a revised analysis utilizing an updated Mars atmospheric model, which showed that the probability of impact for both time intervals easily met the PP requirement. Specifically, for the L+20 to L+50 year period, the probability of impact was shown to be 2.5×10^{-2} . The project report was peer reviewed and eventually approved. The spacecraft is in its third extended mission and in full compliance with PP Requirements."

https://docs.google.com/presentation/d/0Bx_IJbWBrLBLMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



<https://www.gettyimages.com.au/detail/news-photo/the-mars-odyssey-spacecraft-with-gold-foil-protective-news-photo/51598619?adppopup=true>

Mars Odyssey Planetary Protection Category III

"Mars Odyssey's probability of impact estimates before launch were 9.1×10^{-3} for L+20 yrs, and 5.9×10^{-2} for L+20 to L+50 yrs. The latter exceeded the required 5×10^{-2} value and a raise maneuver was planned at the end of the mission to comply.

In the course of the extended missions, the project proposed a revised analysis utilizing an updated Mars atmospheric model, which showed that the probability of impact for both time intervals easily met the PP requirement. Specifically, for the L+20 to L+50 year period, the probability of impact was shown to be 2.5×10^{-2} . The project report was peer reviewed and eventually approved. The spacecraft is in its third extended mission and in full compliance with PP requirements."



https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MiVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1

More photos can be found
using the link(s) below

1. Launch
 - a. https://mars.jpl.nasa.gov/system/resources/detail_files/7791_mars-odyssey-launch-rockett-PIA20331-full2.jpg
2. Artist Rendering
 - a. https://mars.jpl.nasa.gov/system/resources/detail_files/6676_mars-comet-siding-spring-duck-and-cover-orbiters-full2.jpg
 - b. https://mars.jpl.nasa.gov/system/resources/detail_files/3851_PIA04816-full2.jpg
3. Launch
 - a. <https://www.gettyimages.com.au/detail/news-photo/the-2001-mars-odyssey-spacecraft-was-launched-at-at-11-02-news-photo/161008486?adppopup=true>
4. Spacecraft
 - a. <https://www.gettyimages.com.au/detail/news-photo/the-mars-odyssey-spacecraft-with-gold-foil-protective-news-photo/51598619?adppopup=true>





Mars Reconnaissance Orbiter

Mission Type:

Orbiter

Planetary Protection Category:

III

Mission Status Currently Operating

Mars Orbit Insertion March 10, 2006

Launched August 12, 2005

Mars Reconnaissance Orbiter Planetary Protection Category III

"MRO complied with all PP requirements:

- It was assembled in a class 100K clean room with attendant controls

- Provided an inventory of organic materials

- The probability of impact by the launch vehicle, Centaur, was 3.9×10^{-11}

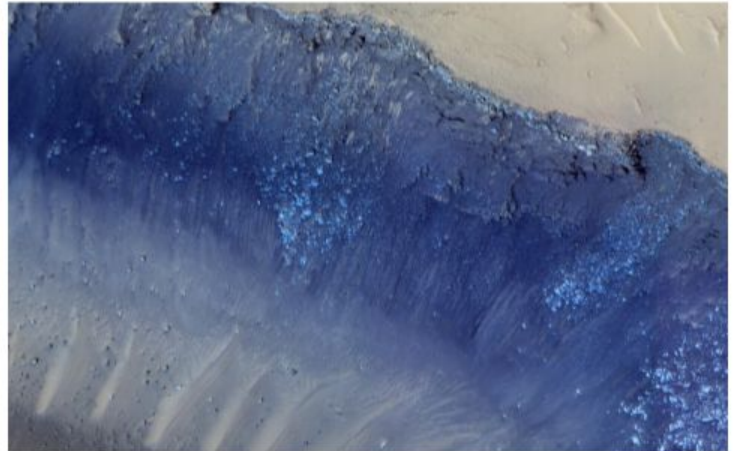
- The total spore burden was 4.4×10^5 , after credit was taken for s/c parts that were shown to reach 500C for .5 sec during burn-up and break-up (a detailed analysis was submitted by the project, peer reviewed, and eventually approved)"

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



More images can be found using the link(s) below

1. Multimedia
 - a. <https://mars.nasa.gov/mro/multimedia/images/>
2. Fact Sheet
 - a. https://www.jpl.nasa.gov/news/fact_sheets/MRO.pdf
3. Spacecraft
 - a. <https://www.jpl.nasa.gov/spaceimages/images/wallpaper/PIA04916-1920x1200.jpg>
4. Getty Images
 - a. <https://www.gettyimages.com/photos/mars-reconnaissance-2005?phrase=mars%20reconnaissance%202005&sort=best>





Mars Science Laboratory Curiosity

Mission Type:

Lander/Rover

Planetary Protection Category:

IVa

Launched: Nov. 26, 2011

Landed on Mars: Aug. 6, 2012

Mars Science Laboratory Curiosity Rover

Planetary Protection Category IVa

"MSL was classified a Category IVa mission and complied with all attendant PP requirements:

The total spore burden on the landed hardware was 5.64×10^4 ($36/m^2$)

The total spore burden in impacting hardware was 1.81×10^5 .

The a-priori probability of impact for the launch and cruise phases was 4.88×10^{-3}

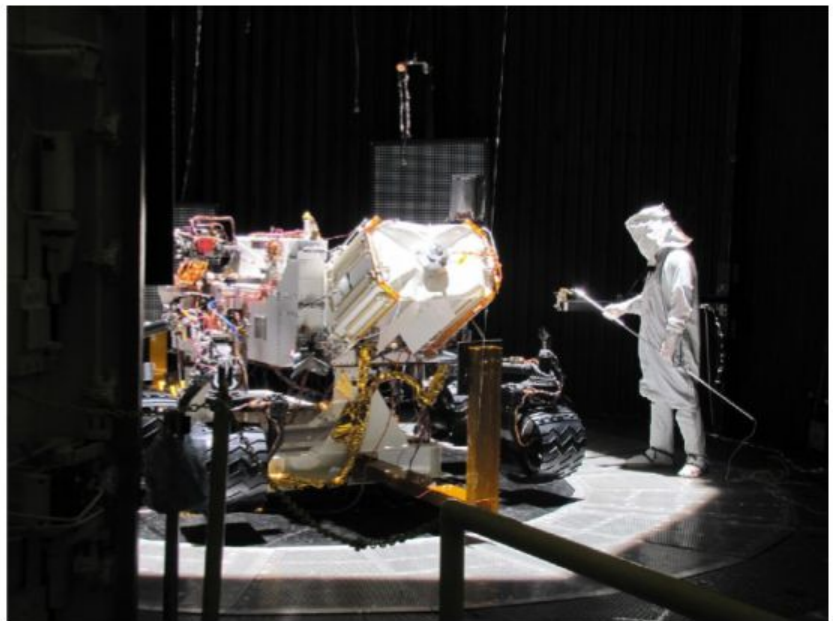
MSL employed cleaning, DHMR treatment, and multiple assays to reduce and monitor the spacecraft's burden"

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYYtM1pJ/edit#slide=id.p1



More photos can be found
using the link(s) below

1. Mission Gallery
 - a. https://www.nasa.gov/mission_pages/msl/images/index.html
2. Multimedia
 - a. <https://mars.nasa.gov/msl/multimedia/>
3. Mission images by Getty
 - a. <https://www.gettyimages.com/photos/mars-rover-curiosity?sort=most-popular&mediatype=photography&phrase=mars%20rover%20curiosity>





Mars Exploration Rovers

Mission Type:

Lander/Rover

Planetary Protection Category:

IVa

Spirit and Opportunity landed on Mars January 3 and January 24, 2004

MER Planetary Protection Category IVa

"The Mars Exploration Rover Mission (MER) is an ongoing robotic mission involving two rovers, Spirit and Opportunity, exploring the planet Mars. Spirit was launched on June 10, 2003, and Opportunity on July 7, 2003; they landed in January 2004, on widely separated equatorial locations on Mars.

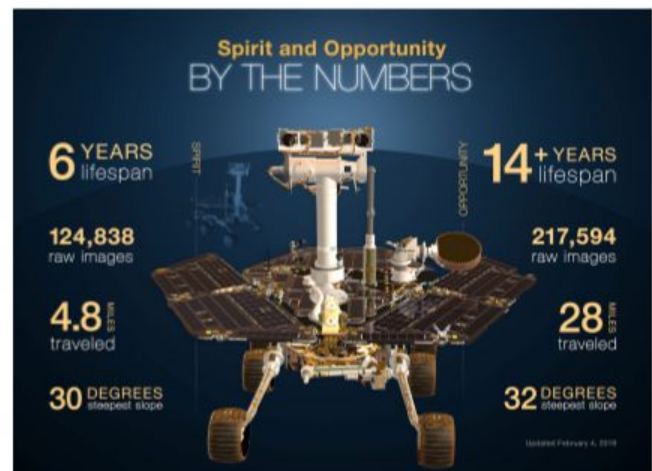
The two rovers complied with all PP requirements:

The landed spore burdens for the two rovers were 1×10^5 for Spirit, and 2.1×10^5 for Opportunity

The spore burdens for the impacting hardware were 1.2×10^5 (39/m²) for Spirit, and 2.1×10^5 (69/m²) for Opportunity

The a priori probabilities of impact for the launch, cruise, and approach phases were 8.95×10^{-3} for Spirit, and 7.71×10^{-3} for Opportunity"

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



More photos can be found
using the link(s) below

1. Multimedia
 - a. <https://mars.nasa.gov/mer/multimedia/images/>
2. Getty Images
 - a. <https://www.gettyimages.com/photos/mars-exploration-rover-spirit?page=3&sort=mostpopular&mediatype=photography&phrase=mars%20exploration%20rover%20spirit>





JUNO

Juno

Mission Type:

Orbiter

Planetary Protection Category:

II

Launch date: August 5, 2011

Juno Mission Planetary Protection Category II*

"Juno was classified a PP Category II*. In addition to documentation requirements, there were probability of impact limits for the Jovian moons and Mars.

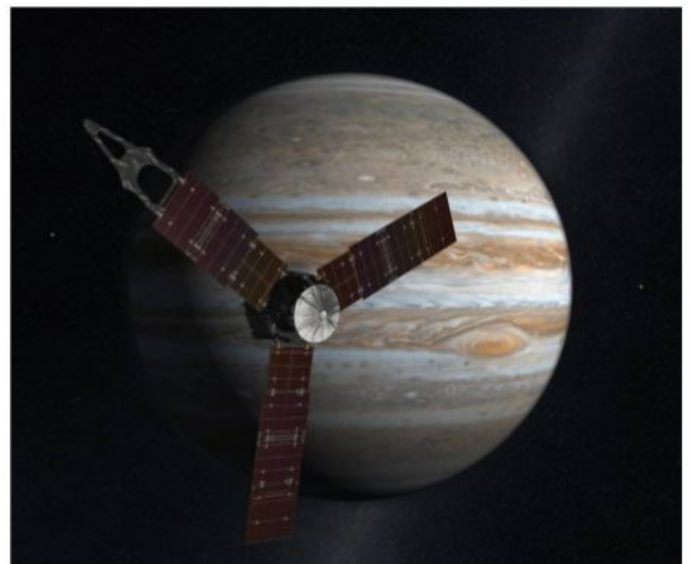
The Juno prelaunch estimates for those probabilities (with the requirement in parenthesis) were:

Probability of contaminating the European ocean, 1.8×10^{-5} (1×10^{-4})

Probability of contaminating any other Jovian moon, 2×10^{-5} (1×10^{-3})

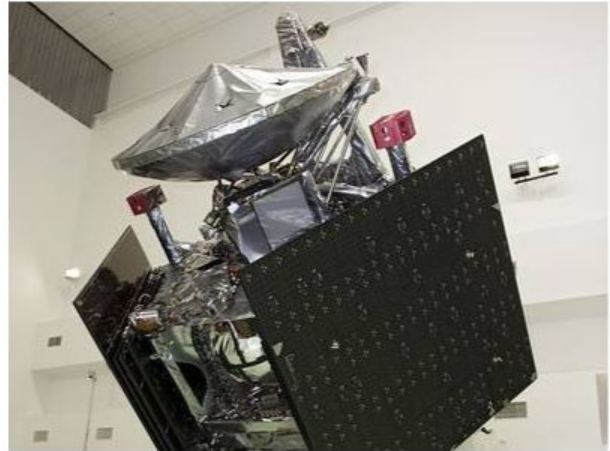
- Probability of impacting Mars, 9.7×10^{-5} (1×10^{-4})"

https://docs.google.com/presentation/d/0Bx_IJbWBrLBMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1



More photos can be found
using the link(s) below

1. Images
 - a. https://www.nasa.gov/mission_pages/juno/images/index.html
2. Fact Sheet
 - a. https://www.jpl.nasa.gov/news/fact_sheets/JUNO_Fact_Sheet_2016.pdf
3. Spacecraft
 - a. <https://inhabitat.com/nasas-juno-spaceship-to-jupiter-will-make-the-most-distant-use-of-solar-power-ever/juno-spacecraft-jupiter-mission-4/>





Dawn

Mission Type:

Orbiter

Planetary Protection Category

II

Launch date: September 27, 2007

Dawn Mission Planetary Protection Category II

"Dawn was classified PP Category II and in compliance with all attendant requirements:

It was assembled in a class 100K clean room . The probability of a Mars impact by the 3rd stage is essentially zero (vs the requirement of 1×10^{-2}) The probability of a Mars impact by the spacecraft is 1.95×10^{-3} (vs the requirement of 1×10^{-2})

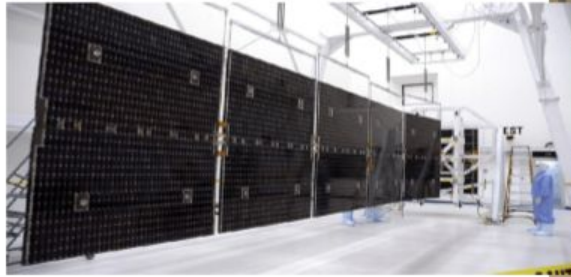
Additionally, it was agreed that any new information on Ceres will be evaluated in time to guide a decision on the final disposition of hardware. Such decision will be subject to approval by the NASA PPO."



https://docs.google.com/presentation/d/0Bx_IJbWBrLBLMVp4MDN6MjVTdGFFU3JtTIM0c1J3RXYtM1pJ/edit#slide=id.p1

More photos can be found using the link(s) below

1. Mission Images
 - a. https://www.nasa.gov/mission_pages/dawn/images/index.html
2. Article from Nasa spaceflight
 - a. <https://www.nasaspaceflight.com/2015/03/dawn-history-c-arrival-ceres/>
3. JPL Dawn spacecraft images
 - a. <https://www.jpl.nasa.gov/spaceimages/details.php?id=PIA12022>
4. https://www.researchgate.net/figure/Dawn-spacecraft-solar-panels-Each-panel-is-image-courtesy-of-NASA_fig1_268556741





Grail

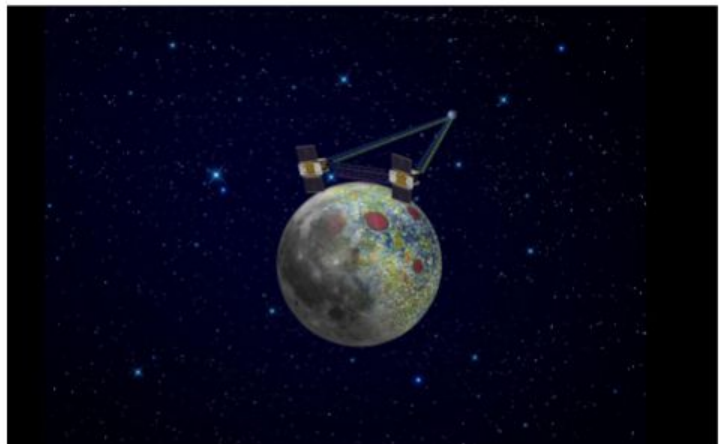
Mission Type:
Orbiter

Planetary Protection Category II
Launch Date: September 10, 2011

Grail Mission Planetary Protection Category II

GRAIL complied with all requirements for a PP Category II mission. The spacecraft was assembled in a class 100K clean room. The GRAIL project conducted a detailed navigation analysis of the trajectory after launch.

The heliocentric upper stage trajectory will never cross the orbit of Mars. Therefore, the probability of impacting Mars is negligible. Per the analysis, there is a 0% chance of the Upper Stage impacting Earth, Mars, or Venus for a 50 year time span (2011-2061). Therefore the GRAIL project is in conformance with PP requirements. An organics inventory was submitted and the final disposition documented.



https://docs.google.com/presentation/d/0Bx_IJbWBrLBLMVp4MDN6MjVTdGFFU3JtITIM0c1J3RXYtM1pJ/edit#slide=id.p1

More photos can be found
using the link(s) below

1. Mission Page Multimedia
 - a. <https://solarsystem.nasa.gov/missions/grail/in-depth/>



<https://www.britannica.com/event/Gravity-Recovery-and-Interior-Laboratory>



Mars Pathfinder

Mission Type:

Rover

Planetary Protection Category:

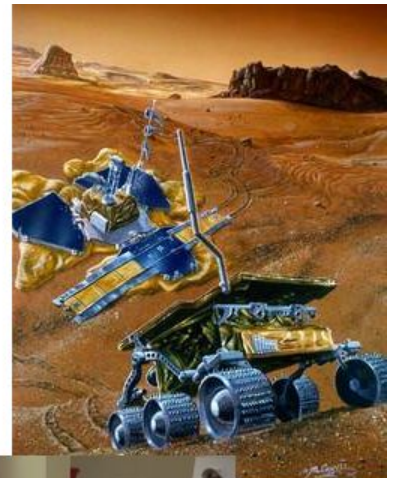
IVa

Launch Date: December 4, 1996

Mars Pathfinder Planetary Protection Category IVa

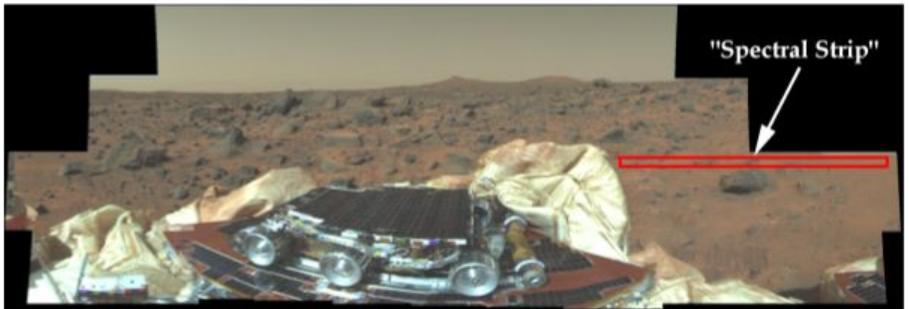
"Pathfinder was assembled in a class 100K clean room with attendant personnel controls and procedures. Cleaning with isopropyl alcohol and frequent assays were used to maintain the spacecraft's microbial cleanliness. Several components were DHMR-treated. Recontamination was minimized by decontaminating the fairing blankets. The surface microbiological burden for the spacecraft was 2.9×10^4 spores, with an average of 14.9 spores/m². The burden of impacting hardware was 7.5×10^4 ."

https://docs.google.com/presentation/d/0Bx_UbWBrLBMVp4MDN6MjVTdGFFU3JlTIM0c1J3RXYlM1pJ/edit#slide=id.p1



More photos can be found
using the link(s) below

1. Website Images
 - a. https://mars.jpl.nasa.gov/Mars_Pathfinder/science/geology.html
 - b. https://mars.jpl.nasa.gov/Mars_Pathfinder/science/mineralogy.html
2. https://en.wikipedia.org/wiki/Mars_Pathfinder#/media/File:Mars_Pathfinder_Lander_preparations.jpg



Powerpoint Slideshows, documents, and other resources that can be used for content for training purposes.

1. Planetary Protection Training course Lectures & PPTs
 - a. <https://drive.google.com/drive/folders/1NI0dI-UIBh-H4dImd9nNMfF4qMsPzgl9>
2. Current Articles in the Public Domain that contain quotes from Planetary Protection Officers.
 - a. <https://docs.google.com/presentation/d/1luwwPvZAidkeXyspkxt0PXikU0p1Y6UZBLYLj41Bud4/edit?usp=sharing>