Jet Propulsion Laboratory
California Institute of Technology

Joint Audit Planning Committee (JAPC)

JAPC Monthly Meeting

Planetary Protection

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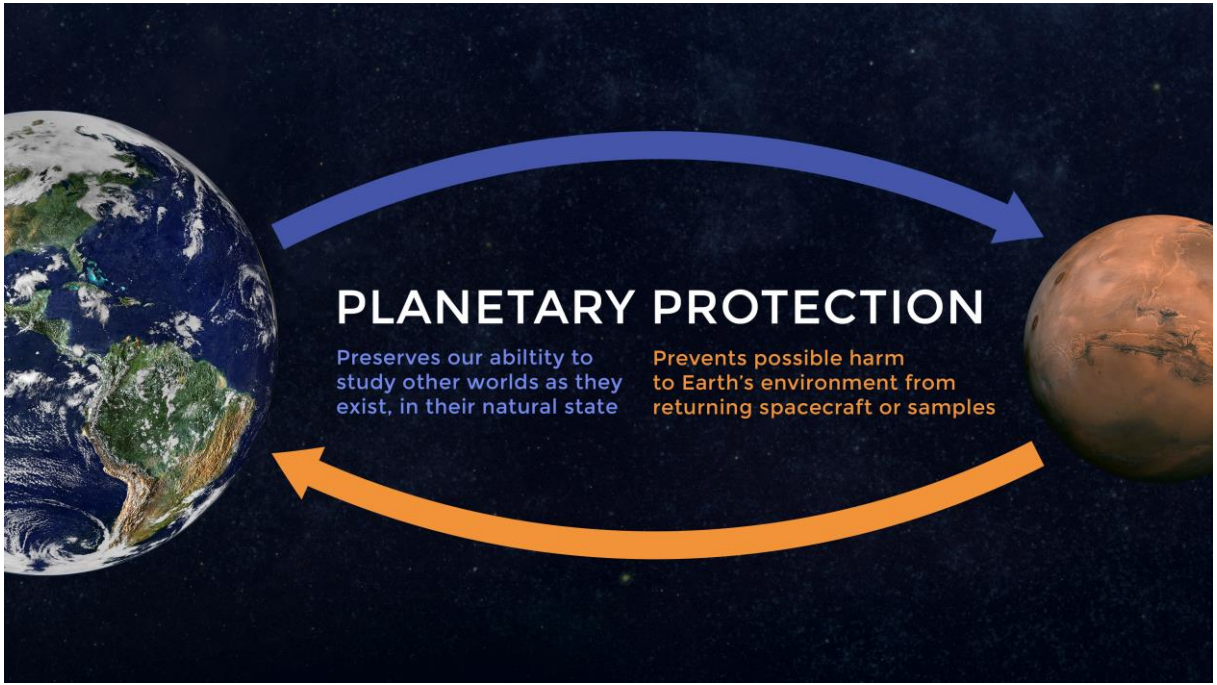
Background

What is Planetary Protection (PP)?

- **Planetary Protection** is a guiding principle in the design of an interplanetary mission, aiming to prevent biological contamination of both the target celestial body and the Earth
- Planetary Protection reflects both the unknown nature of the space environment and the desire of the scientific community to preserve the pristine nature of celestial bodies until they can be studied in detail

Background

Planetary Protection: **Forward** and **Backward** contamination

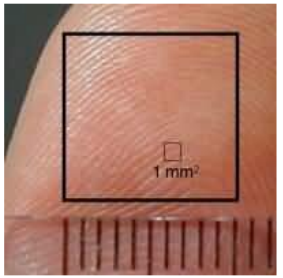


Background

Human contribution

- Biggest threat to hardware cleanliness is people
  - Skin flakes, hair, spittle droplets, fingerprint residue, clothing fibers, cosmetics, footwear dirt, bacteria and viruses

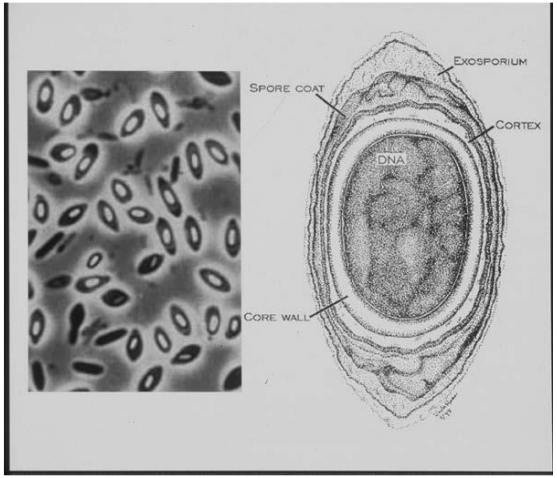
- There are 10x more microbial cells than human cells in your body
  - 10000 bacteria on 1 cm^2 skin
  - 100 bacteria on 1 mm^2 skin



Background

What organisms do we worry about?

- Bacterial Endospores (Spores) are the most resistant organisms to heat sterilization
  - Subcellular body formed when conditions not favorable for growth
  - Resistant to harsh conditions (temperature, heat, drying, radiation, acids, disinfectants etc.)
  - Can remain dormant for >10^7 years
  - Convert back to vegetative cells quickly
  - Used as basis of PP requirements to determine microbial bioburden of hardware



Bacillus spores

PP Implementation Approach

NASA Documents

- Biological Contamination Control for Outbound and Inbound Planetary Spacecraft NPD 8020.7G, February 19, 1999 (Revalidated 5/17/13 with 1 change).
- NASA Policy on Planetary Protection Requirements for Human Extraterrestrial Missions NPI 8020.7
- Planetary Protection Provisions for Robotic Extraterrestrial Missions, NPR 8020.12D, April 20, 2011.
- NASA Handbook for the Microbiological Examination of Space Hardware, NASA-HDBK-6022, Rev. Initial, August 17, 2010.

PP Implementation Approach

PP Documents

- **Planetary Protection Plan** documents how a flight project meets its Planetary Protection requirements.
- **The Planetary Protection Implementation Plan** then describes how the Planetary Protection Plan is to be implemented.
- Subsidiary documents such as the **Microbial Reduction Plan** provides information on how hardware is microbially reduced to a specified level. The **Microbiological Assay Plan** discusses the sampling technique and procedure (culture) for the enumeration of the spores from the samples.

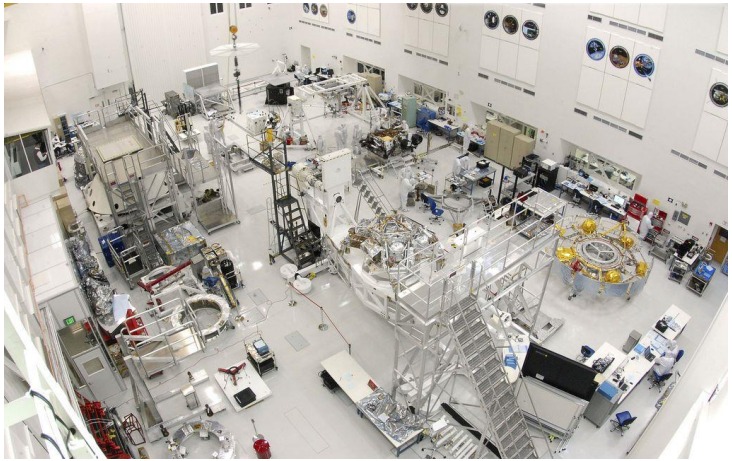
PP Implementation Approach

PP Process

- Prepare a request for a project planetary protection category
- Conduct preliminary analysis of PP needs and participate as a member of design teams to ensure PP requirements are included in the design
- Develop the PP plan
- Develop PP implementation documents addressing:
  - How hardware is to be cleaned/microbially reduced/sterilized and kept clean
  - How hardware cleanliness is to be determined
  - Verification methodology
  - How microbial burden budget is to be sub-allocated
  - How impact probability requirements are to be met
  - Any special project procedures or analyses required
  - Any garmenting protocols/specifications, integration and test facility cleanliness needs, launch site support requirements, and launch vehicle and related launch complex cleanliness needs
  - Specific requirements (e.g., such as heat microbial reduction, HEPA filter) imposed on each hardware item

PP Implementation Approach

PP Categories



Mission Type	Types of Planetary Bodies	Types of Bodies	Category
Flyby, Orbiter, Lander	Planetary Protection requirements not obligated as there is no origin-of-life interest.	Undifferentiated, metamorphosed asteroids	I
Flyby, Orbiter, Lander	Bodies where there is an origin-of-life interest and rare chance that contamination carried by a spacecraft could jeopardize future missions.	Venus; Moon; Comets; Asteroids; Jupiter; Saturn	II
Flyby, Orbiter	Bodies where there is an origin-of-life interest and there is a significant chance that contamination carried by a spacecraft could jeopardize future missions. PP documentation and implementation required.	Mars; Europa; Enceladus	III
Lander, Probe	Bodies where there is an origin-of-life interest and there is a significant chance that contamination carried by a spacecraft could jeopardize future missions. PP documentation and implementation required. Category IV missions for Mars are subdivided into IVa, IVb, and IVc.	Mars; Europa; Enceladus	IV
Restricted Earth-Return	Earth-return missions from bodies with significant risk of backward contamination. Requires containment of any unsterilized samples collected and returned to Earth.	Mars; Europa; Enceladus	V (restricted)
Unrestricted Earth-Return	Earth-return missions from bodies “deemed by scientific opinion to have no indigenous life forms.” Category I and II PP requirements suffice.	Venus, Moon	V (unrestricted)

PP Implementation Approach

General Approach

- Bioburden of external surfaces of the spacecraft and its subsystems will be controlled by solvent cleaning and contamination procedural and facility controls during the assembly and test
- Selected systems will undergo Heat Microbial Reduction (HMR)
- Bioassays will be performed during the spacecraft assembly and test
- Recontamination will be prevented by maintaining hardware in clean rooms, draping hardware as much as possible, the use of clean room garments and glove requirements
- The bioburden on other surfaces, and as applicable, the encapsulated bioburden in non-metallic material volumes, may be estimated per PP specifications
- HEPA Filters on the depressurization vents of enclosed electronic modules can be used to reduce the accountable areas

PP Implementation Approach

HMR

- **Heat Microbial Reduction (HMR)** is the typical standardized microbial reduction process used and approved by the NASA PPO (other processes such as Vapor Hydrogen Peroxide are becoming available for consideration)
- HMR is employed on assemblies with large surface areas, those that are difficult to clean or possess limited access, and on assemblies with encapsulated bioburden in bulk materials Honeycomb Structure
  - MLI
  - Backshell/Heat Shield
  - Cabling
  - Electronic Components

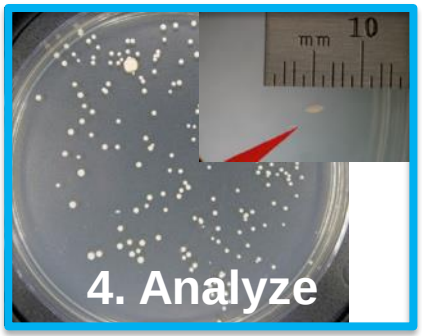
PP Implementation Approach

NASA Standard Assay

- Goal is to sample 10 % of the surface area to get statistically significant results
- The NASA Standard Assay uses two types of surface sampling: Swabs and Wipes
  - The swab method is utilized for smaller hardware surfaces (less than $1m^2$) where each swab can sample a surface no greater than $25cm^2$.
  - Wipe sampling is preferred for any suitable surface at least 0.1 m^2 in area, where each wipe can sample a surface no greater than $0.7m^2$.
  - During sampling, aseptic technique is used (i.e., sterile gloves, sterile forceps, sterile wipes, sterile swabs, sterile containers, etc.).

PP Implementation Approach

Bioassay Sampling and Processing



- Hardware cleaned and bioassayed at their last planned physical access point
- Sample hardware via Swab or Wipe (water is used as solvent)
- Process swabs and wipes (sonication, heat shock, plating, agar)
- Analyze plates - count @ 24h, 48h, and 72h

PP Implementation Approach

Recontamination Prevention

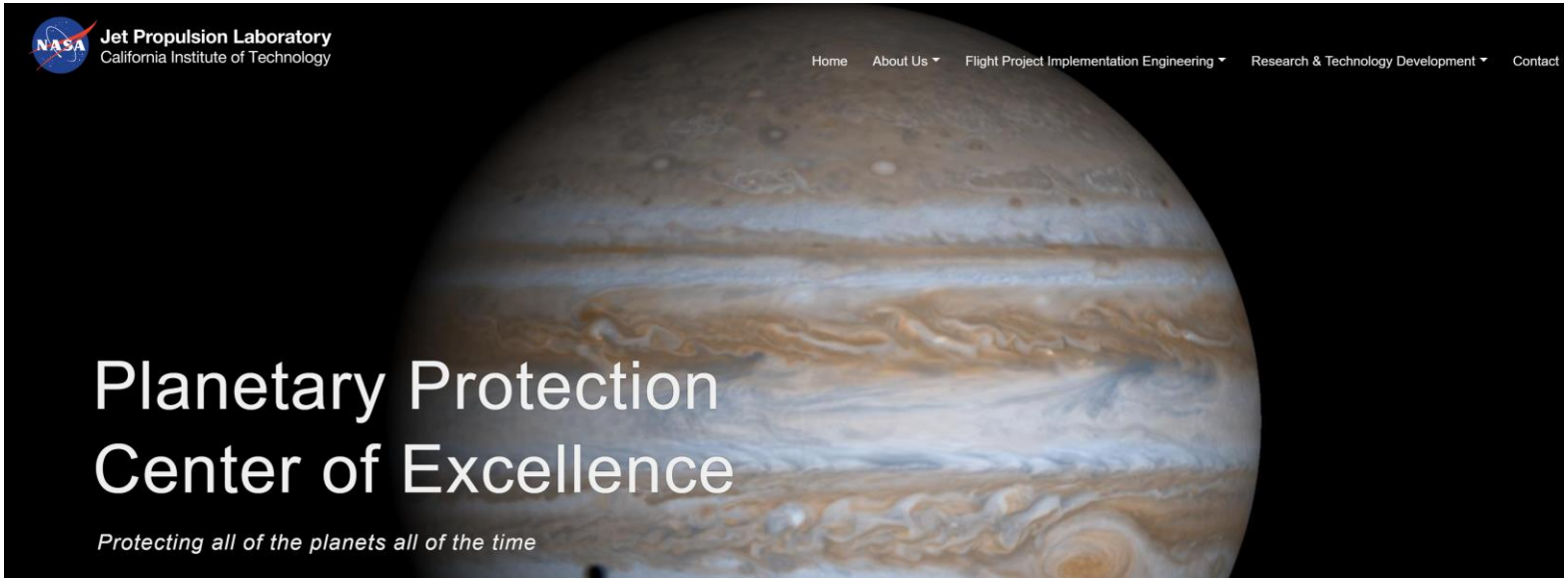
- Cleanroom facilities and the personnel will be controlled
- Work bench should be cleaned first thing in the morning and before putting down any hardware
- After having been cleaned and bioassayed at their last planned physical access point, hardware surfaces will immediately be covered or closed-out (by an abutting assembly)
    - Vents should be covered via filters/tape
        - During thermal vacuum testing, the vents and apertures must be open to allow de-pressurization and re-pressurization
- Hardware processed by heat microbial reduction protected via
    - (A) the clean package in which the HMR process is performed (preferred)
    - (B) its own enclosure, in which case only the internal surfaces are considered as having been treated
    - (C) placing it inside two clean storage bags immediately after HMR, properly sealed, in which case the external surfaces may be considered as having been treated but will be subject to verification
- All test fixtures, chamber walls, and associated GSE will be cleaned and bioassayed prior to coming in contact with any flight system

NASA Planetary Protection Website

https://planetaryprotection.nasa.gov/

JPL Planetary Protection Website

https://planetaryprotection.jpl.nasa.gov/



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