# Day-to-day Operations of the Planetary Protection Office: Past, Present, and Future

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NASA Planetary Protection Officer

23 May, 2017

# Outline



- Introduction
- Past: Apollo, Viking, and Advice
- Present: Interfaces and Interactions
- Future: Reorganization

# Foundations of Planetary Protection



## NASA Policy Directive 8020.7

1. a. It is NASA's policy to comply with planetary protection provisions in support of U.S. obligations under the 1967 Outer Space Treaty, which are founded on the following policy statement:

(1) 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 or other extraterrestrial sources. Therefore, for certain space-mission/target-planet combinations, controls on organic and biological contamination carried by spacecraft shall be imposed in accordance with directives implementing this policy.

## The Outer Space Treaty of 1967

Article IX states that:

> "...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..."

# Planetary Protection Considerations for Robotic and Human Missions



- Avoid contaminating target bodies that could host Earth life (e.g., Mars, Europa, Enceladus)
- Ensure biohazard containment of samples returned to Earth from bodies that could support native life (e.g., Mars and possibly moons, Europa, Enceladus)
- On human missions, characterize and monitor human health status and microbial populations (flight system microbiome) over the mission time, to support recognition of alterations caused by exposure to planetary materials

Earth's Moon,
Most Solar System Bodies

Documentation only;
No operational constraints on *in situ* activities or sample return

Phobos/Deimos

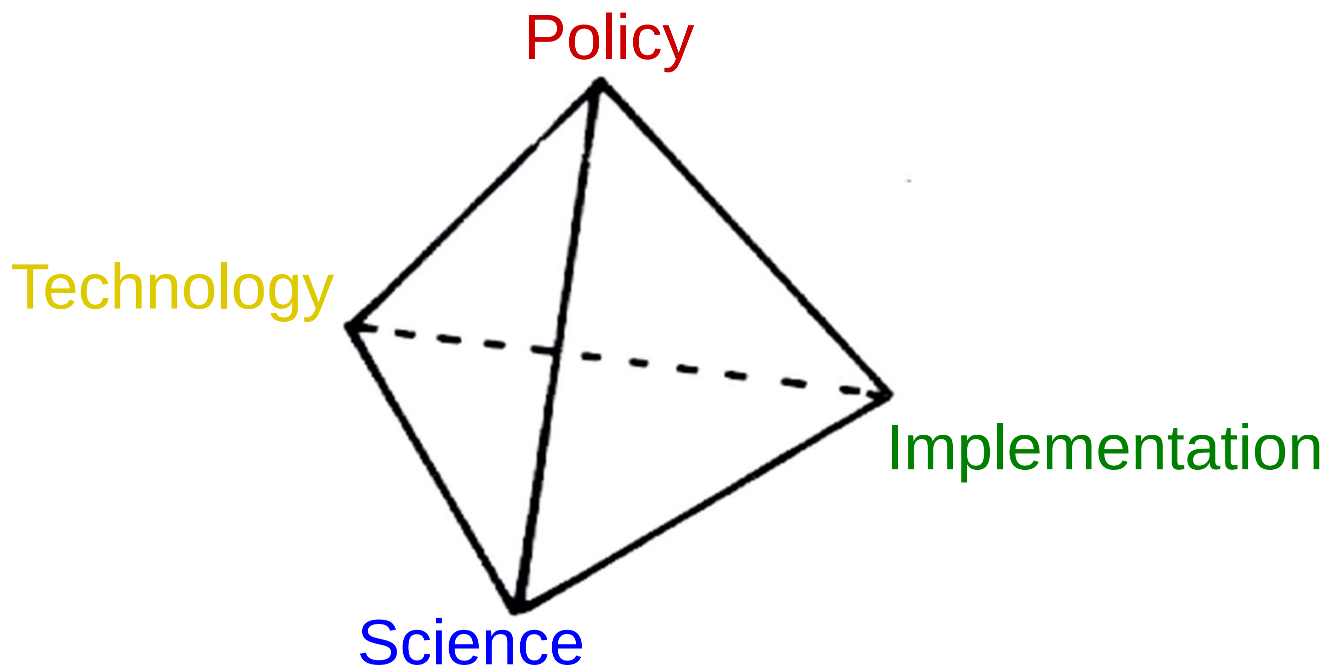
Document *in situ* activities;
Possible return constraints (Phobos requirements currently under study)

Mars, Europa, Enceladus

Documentation and operational restrictions to avoid introducing Earth life;
Strict biohazard containment of returned samples

# Elements of Planetary Protection






Mission Oversight and Monitoring

Policy and Requirements Coordination

Scientific Research and Technology Development

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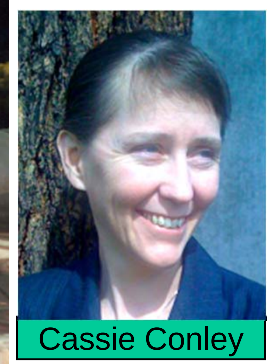
# Planetary Quarantine/Protection Officers




1963-1976
(PQO)


2006-present
(PPO)

1976-1979
(PQO)

1979-1986
(PQO/PPO)

1986-1993
(PPO)

1993-1997
(PPO)

Rummel II
1997-2006
(PPO)

# Apollo-era Restricted Earth Return



Concerns for human missions include both health and safety of the astronauts, and also assuring low risk to the environment of the Earth due to the return of astronauts carrying planetary materials

# Apollo-Era Restricted Earth Return: Oversight of 'Back Contamination' under NASM 235



1963 The NAS Space Science Board recommends that NASA establish a quarantine program 'to ensure that Earth and its ecology would be protected from any possible hazard associated with the return of lunar material'

1963 Interagency Committee on Back Contamination (ICBC) is formed, with representatives from Public Health, Agriculture, and Interior, as well as NAS and NASA

1965 Is determined that Public Health Service should be responsible for the back contamination aspects of the Lunar Receiving Laboratory

1967 NASA, the Public Health Service, the Dept. of Agriculture, and the Dept. of the Interior sign an Interagency Agreement on Back Contamination, and formally charter the ICBC as the coordinating body for oversight of returned lunar astronauts and samples

1969 ICBC meets to evaluate the Apollo 11 returned sample test results

1971 Apollo Lunar Quarantine Program is ended

# National Security Action Memo 235: Large-scale Scientific or Technological Experiments with Possible Adverse Environmental Effects



Signed on 17 April 1963

– "Experiments which by their nature could result in domestic or foreign allegations that they might have such effects will be included in this category even though the sponsoring agency feels confident that such allegations would in fact prove to be unfounded."

1) Agency Head must report proposed experiments to the advisor for Science and Technology sufficiently early to conduct appropriate reviews.

2) Agency must provide a detailed evaluation of the experiments' importance, and possible direct or indirect environmental effects.

...

4) The advisor "... may request that additional studies be undertaken by the sponsoring agency or he may undertake an independent study of the problem."

...

7) "...there should be early and widespread dissemination of public information explaining experiments..."

8) "...the National Academy of Sciences and where appropriate international scientific bodies or intergovernmental organizations may be consulted in the case of those experiments that might have adverse environmental effects beyond the U.S."

# Apollo-Era Restricted Earth Return: US Government Interagency Coordination



SSB recommended formation of a quarantine program in 1963

– The Interagency on Back Contamination (ICBC) included representatives from public health, agriculture, & interior. In 1964 the ICBC approved designs for the Lunar Receiving Laboratory (LRL) and pursued ad-hoc studies to support construction. In 1965, NASA determined that Public Health Service should be responsible for the back contamination aspects of the LRL

The ICBC was formally chartered in 1967, under an Interagency Agreement on "the protection of the Earth's biosphere from lunar sources of contamination"

– The interagency agreement would "confirm existing arrangements between the parties hereto relating to the protection of the Earth's biosphere from lunar sources of contamination, and provides for certain additional arrangements, including the designation of officials authorized to represent and act for each of the parties"

– Regulatory agencies included the Department of Agriculture, the Department of Health, Education and Welfare, and the Department of the Interior; additional members from the National Academy of Sciences and NASA

– Consultation with regulatory agencies was required before taking action "unless such action is in accordance with the unanimous recommendation of the agencies represented on the Interagency Committee on Back Contamination."

# Apollo-Era Restricted Earth Return: The Interagency Committee on Back Contamination



- NASA "must draw upon the specialized knowledge and experience of certain other agencies in order to protect the public's health, agriculture, and other living resources against the possibility of contamination resulting from returning lunar astronauts or lunar exposed material, and to preserve the biological and chemical integrity of lunar samples and the scientific experiments relating thereto"
- ICBC "shall advise the Administrator concerning back contamination and the protection of the biological and chemical integrity of lunar samples.

(1) Consider and make recommendations concerning proposed quarantine protocols

(2) Review the plans and specifications of the Lunar Receiving Laboratory, and recommend approval of procedures and standards for containment testing.

(3) Conduct inspections of the Lunar Receiving Laboratory during its construction, upon its completion, and immediately prior to manned lunar missions.

(4) Review and recommend the manner in which lunar astronauts, lunar samples, mission-related equipment, and other lunar exposed material are to be recovered and transported to places of quarantine.

(5) Review and recommend approval of quarantine procedures and tests, analyses, and other examinations on lunar astronauts, lunar samples, mission-related equipment, and other lunar exposed material.

...

It is anticipated that among important functions of the Committee will be that of advising the Administrator as to when and the manner in which astronauts and lunar samples may be released from quarantine."

# Learning from Past Experience



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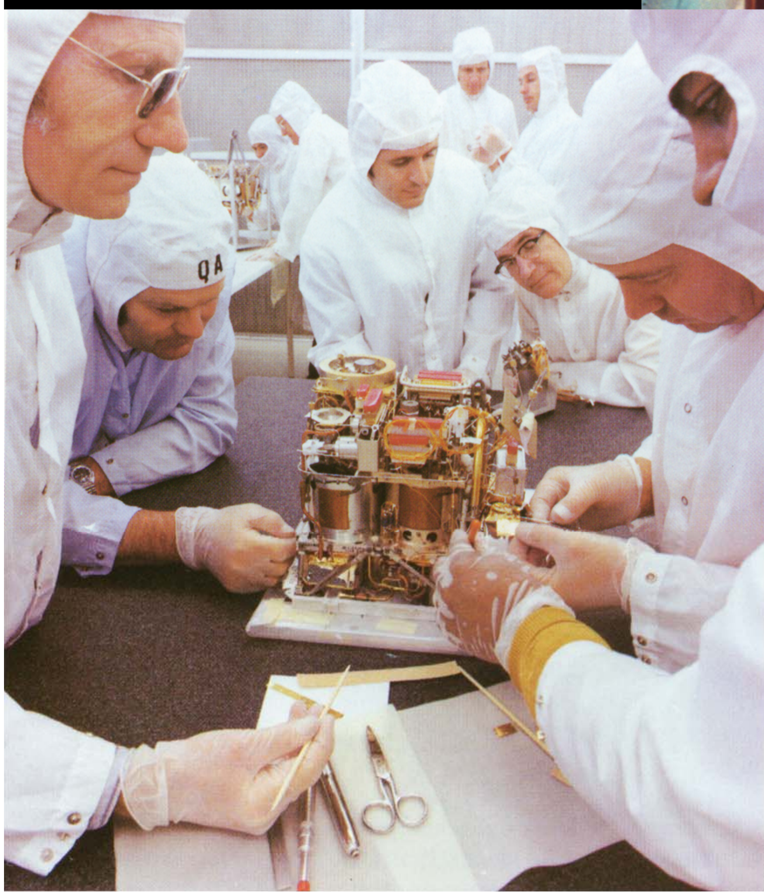
# In Situ Life Detection: Clean and Sterilize

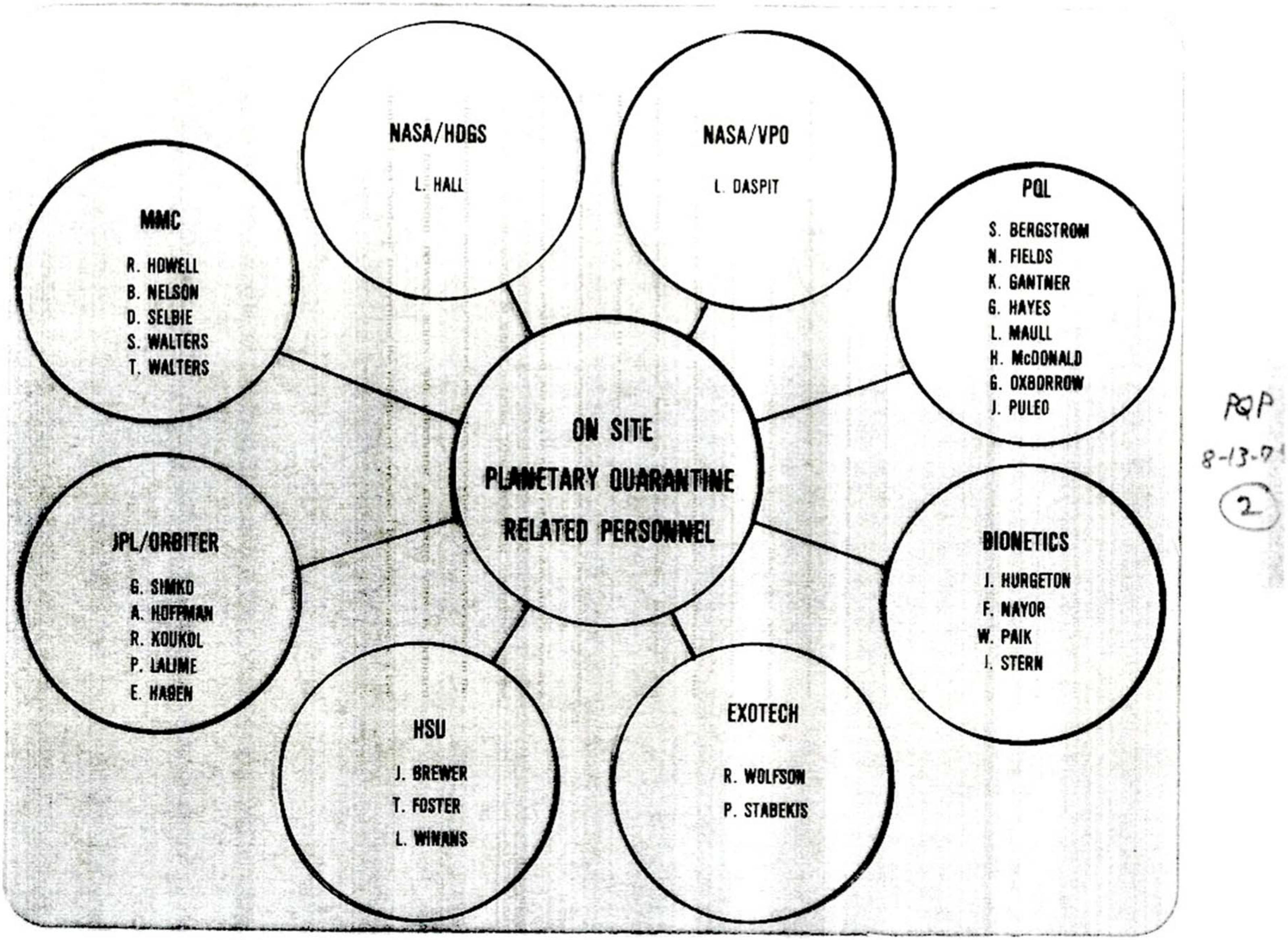


Viking Life Detection Package

Terminal Sterilization Works...

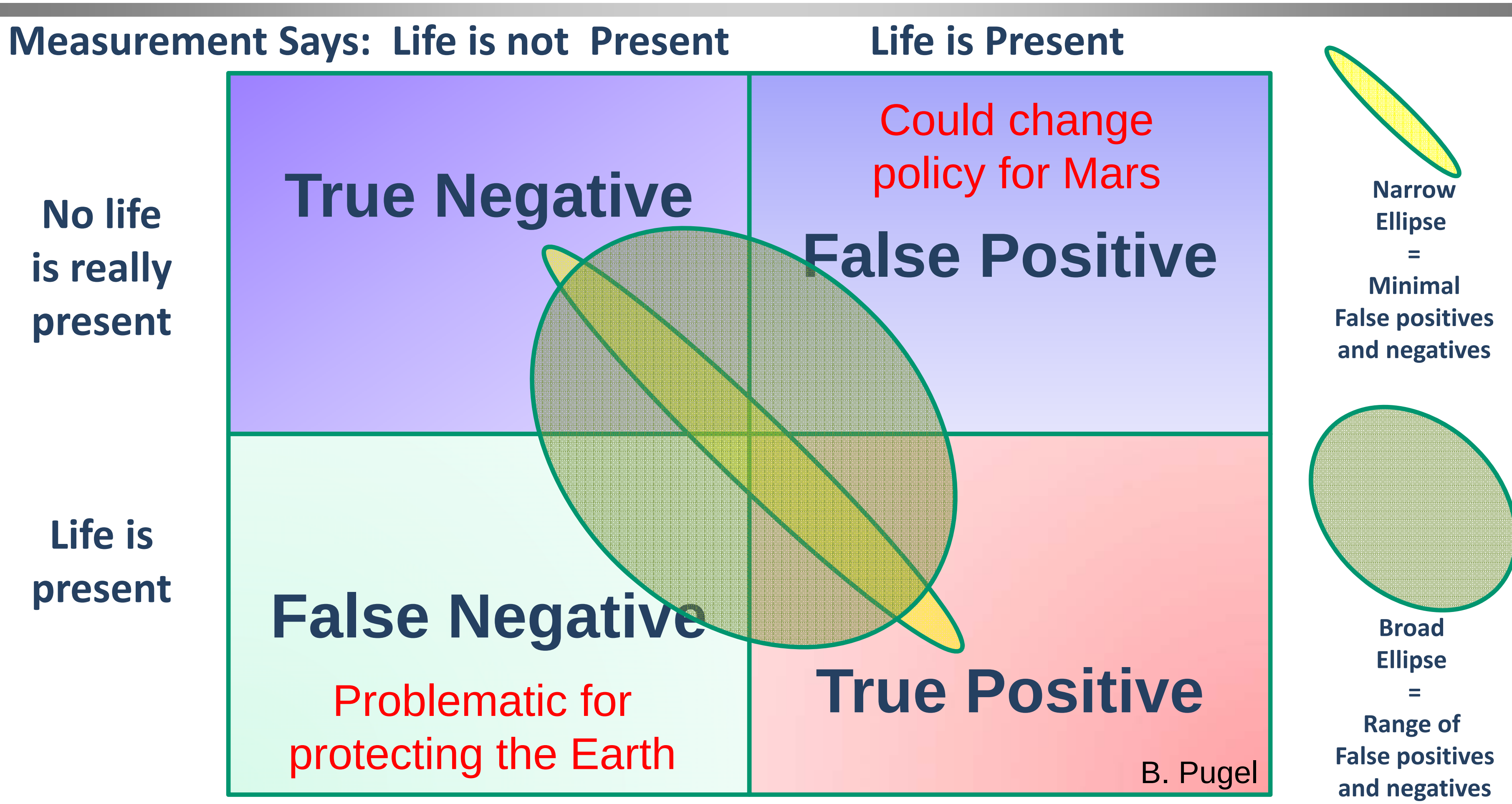
# Viking Planetary Quarantine (PQ) Team

(chart dated 8-13-75)



# Organic Contamination and Life Detection






"NASA should sponsor research on nonliving contaminants of spacecraft ... and their potential to confound scientific investigations or the interpretation of scientific measurements, especially those that involve the search for life."

-- SSB, 2006

# Viking Planetary Protection: Costs and Lessons Learned



## The two life detection instruments each cost ~10% of Viking total

**Table 43**

Cost History of Viking Lander and Selected Subsystems (in millions)

| Date | Estimated Cost at Completion | | | | | Total Lander Actual Cost |
|---|---|---|---|---|---|---|
| | Biology | GCMS | Lander Camera | GCSC | Total Lander | |
| 3 June 1970 | - | 17.8 | - | - | 360 | 19 |
| Sept. 1970 | 13.7 | 20.6 | 9.8 | 3.4 | - | - |
| Aug. 1971 | 17.0 | 25.0 | 12.9 | - | 401 | 62 |
| Feb. 1972 | 34.5 | 35.0 | 17.4 | - | 381 | 107 |
| July 1972 | 32.3 | 35.0 | 18.1 | 10.2 | 420 | 149 |
| Apr. 1973 | 29.2 | 35.4 | 22.9 | 10.2 | 430 | 286 |
| Mar. 1974 | 44.2 | 38.7 | 23.1 | 24.1 | 512 | 411 |
| July 1974 | 50.3 | 39.9 | 27.4 | 24.7 | 543 | 451 |
| Sept. 1974 | 55.0 | - | 23.5 | 28.1 | 559 | 473 |
| Mar. 1975 | 59.0 | 41.0 | 27.5 | - | 545 | 545 |
| June 1976 | 59.5 [a] | 41.2 [a] | 27.3 [a] | 28.1 | - | 553.2 [a] |

[a] Actual cost incurred.
GCMS = gas chromatograph-mass spectrometer.
GCSC = guidance, comrol, and sequencing computer

LESSONS LEARNED
FROM THE
VIKING PLANETARY QUARANTINE
AND
CONTAMINATION CONTROL EXPERIENCE

for

Contract NASW-4355
NASA Headquarters
Washington, DC

The Bionetics Corporation
2 Eaton Street
Hampton, VA 23669

## The work done to validate system-sterilization made for a more reliable mission

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# Returned Samples:
# How Good is Good Enough?



NASA/CP—2002–211842

A DRAFT TEST PROTOCOL
FOR DETECTING POSSIBLE BIOHAZARDS IN
MARTIAN SAMPLES RETURNED TO EARTH

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October 2002

Protecting the Earth and performing science have many clear synergisms – however:

**The highest priority when studying extraterrestrial samples is to prevent harm to the Earth**

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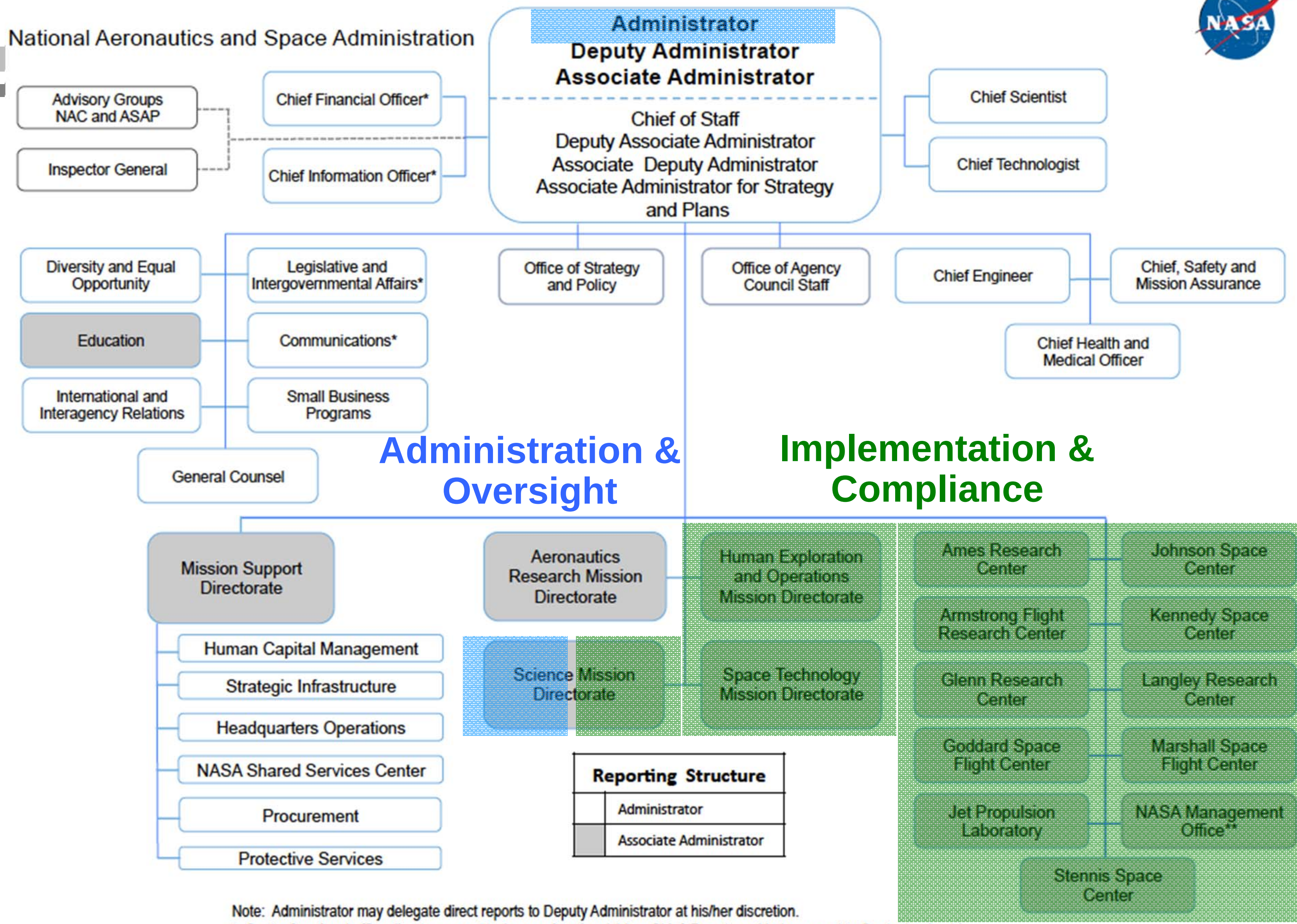
# NASA Planetary Protection Policy



- NPD 8020.7G "Biological Contamination Control for Outbound and Inbound Planetary Spacecraft" states policy, describes roles and responsibilities *(approved by NASA Administrator)*
  - The Planetary Protection Officer acts on behalf of the Associate Administrator for Science to maintain and enforce the policy
  - NASA obtains recommendations on planetary protection issues (requirements for specific bodies and mission types) from the National Research Council's Space Studies Board
  - Advice on policy implementation is obtained from the NAC Planetary Protection Subcommittee (currently not active)
- NPR/NID 8020.12D "Planetary Protection Provisions for Robotic Extraterrestrial Missions" *(approved by SMD Associate Administrator)*
  - Describes documentation and implementation requirements for forward and back-contamination control
  - NPI 8020.7 "NASA Policy on Planetary Protection Requirements for Human Extraterrestrial Missions" (*approved by SMD and HEO Associate Administrators)*
- NASA supports international missions when COSPAR policy is followed

# NASA Policy Directive 8020.7: Roles and Responsibilities




Note: Administrator may delegate direct reports to Deputy Administrator at his/her discretion.
* Center functional office directors report to Agency functional AA or Chief. Deputy and below report to Center leadership.
** NMO oversees the Jet Propulsion Laboratory and other Federally Funded Research and Development Center work

*November 2015*

a. The Associate Administrator for the Science Mission Directorate, or designee, is responsible for overall administration of NASA's planetary protection policy. This includes the following:

(1) Maintaining the required activities in support of the planetary protection policy at NASA Headquarters.

(2) Assuring that the research and technology activities required to implement the planetary protection policy are conducted.

(3) Monitoring space flight missions as necessary to meet the requirements for planetary protection certification.

b. The Planetary Protection Officer shall be responsible for the following, as the designee of the SMD AA:

(1) Prescribing standards, procedures, and guidelines applicable to all NASA organizations, programs, and activities to achieve the policy objectives of this directive.

(2) Certifying to the Associate Administrator for the Science Mission Directorate and to the Administrator prior to launch; and (in the case of returning spacecraft) prior to the return phase of the mission, prior to the Earth entry, and again prior to approved release of returned materials, that--

(a) All measures have been taken to assure meeting NASA policy objectives as established in this directive and all implementing procedures and guidelines.

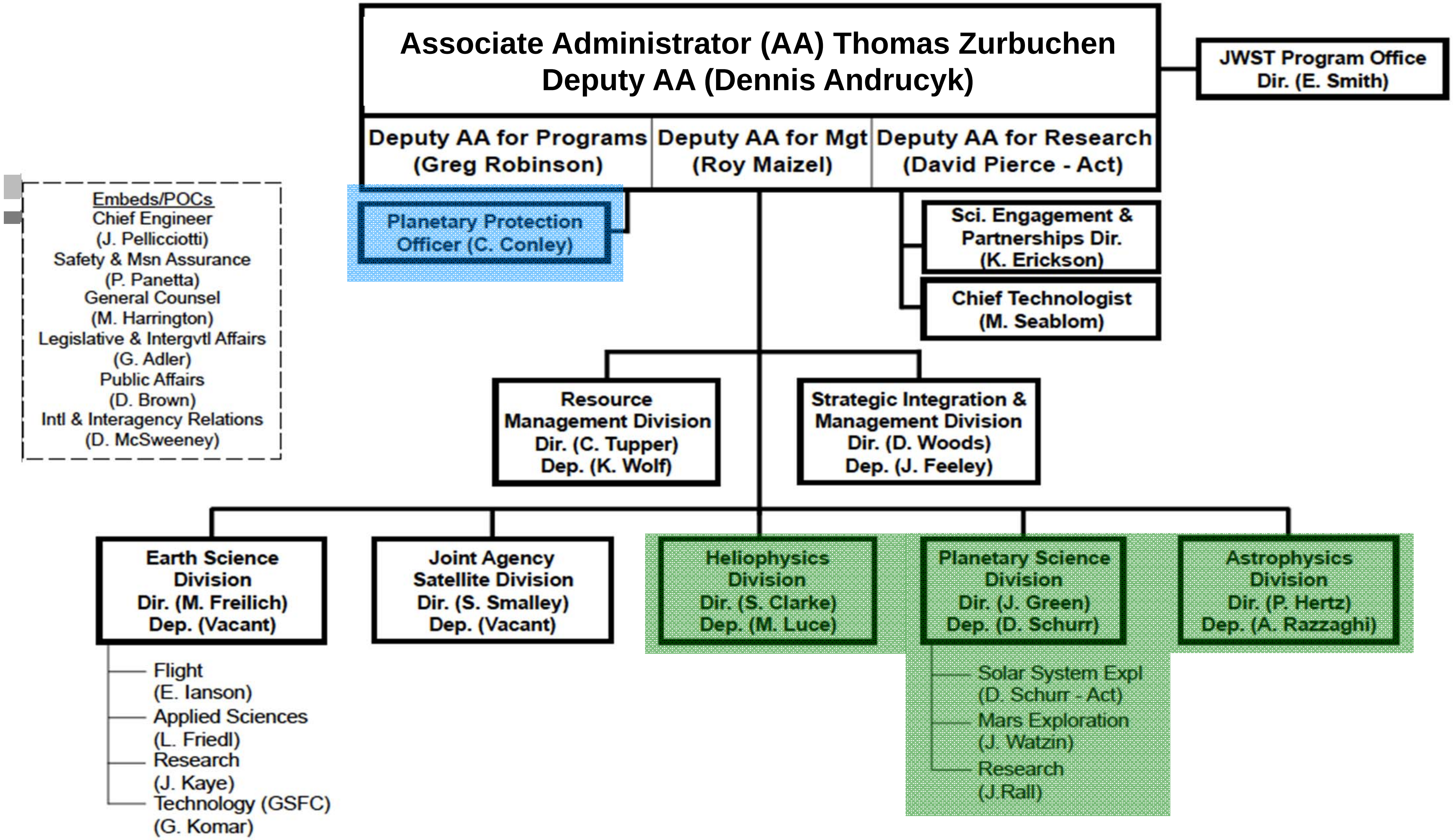
(b) The recommendations, of relevant regulatory agencies with respect to planetary protection have been considered, and pertinent statutory requirements have been fulfilled.

(c) The international obligations assessed by the Office of the General Counsel and the Office of External Relations have been met, and international implications have been considered.

(3) *Conducting reviews, inspections, and evaluations of plans, facilities, equipment, personnel, procedures, and practices of NASA organizational elements and NASA contractors, to discharge the requirements of this directive.*

(4) Keeping the Associate Administrator for the Science Mission Directorate informed of developments and taking actions as necessary to achieve conformance with applicable NASA policies, procedures, and guidelines.

c. The Associate Administrator for the Human Exploration and Operations Mission Directorate and the Associate Administrator for the Space Technology Mission Directorate, or designees, will ensure that applicable standards and procedures established under this policy, and detailed in subordinate implementing documents, are incorporated into human space flight missions. Any exceptions will be requested and justified to the Administrator through the Associate Administrator for the Science Mission Directorate.




d. Program Managers, through their respective Center Director, will be responsible for the following:

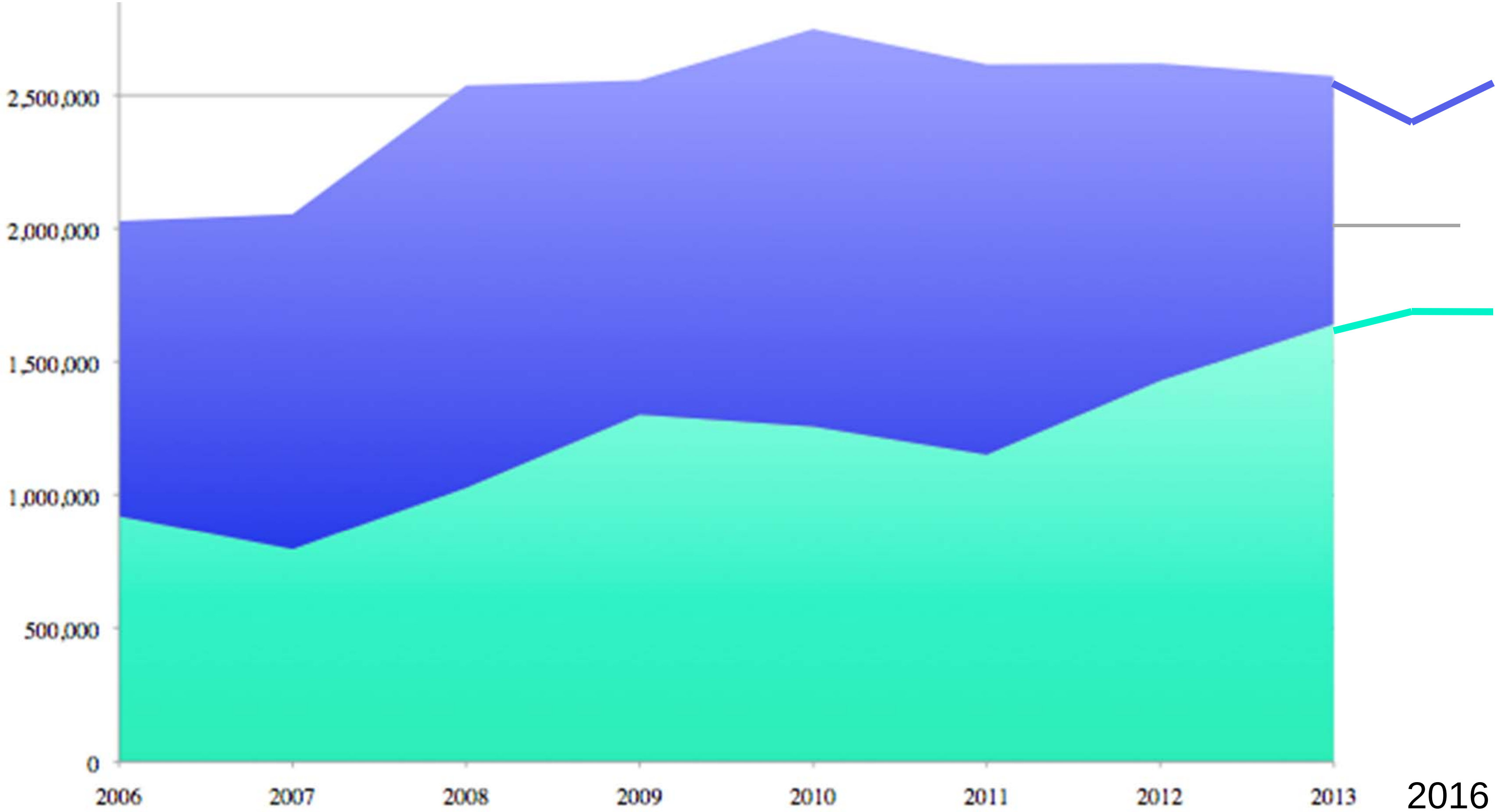
(1) Meeting the biological and organic contamination control requirements of this directive and its subordinate and implementing documents during the conduct of research, development, test, preflight, and operational activities.

(2) Providing for the conduct of reviews, inspections, and evaluations by the Planetary Protection Officer, pursuant to this directive.

# Planetary Protection Budget

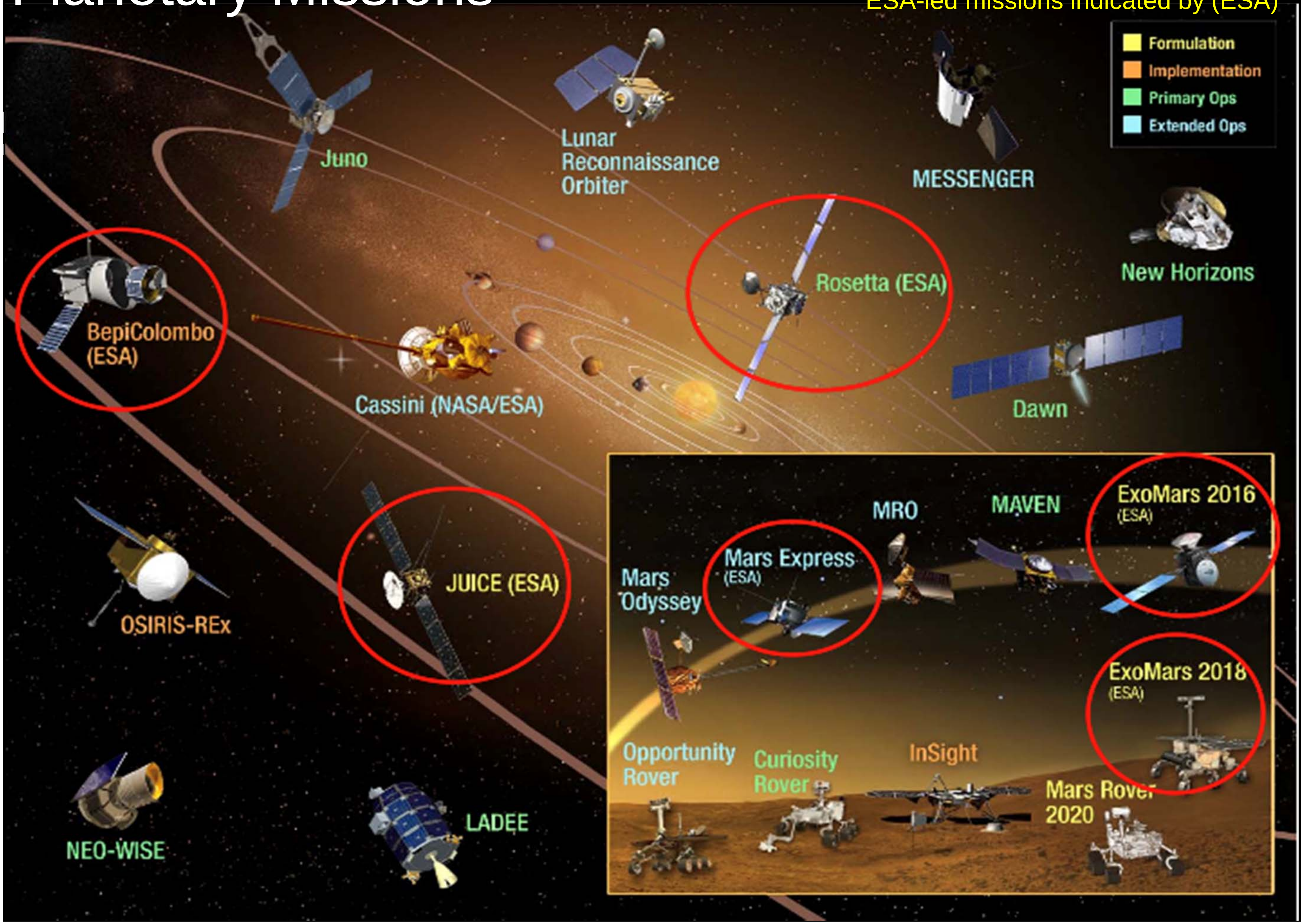


Proposals to PPR in ROSES 2015
Programmatic needs being assessed



# Planetary Missions

Nearly all NASA missions have multiple-agency contributions;
ESA-led missions indicated by (ESA)



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# New Structure for Planetary Protection

## Chief, S&MA

- Authority to Accept Risk on Behalf of the Public at Low Levels, Reports all Public Risk to Administrator
- Responsible for PP/CC mitigation policy and oversight consistent with COSPAR planetary protection policy.
- Acts as cognizant Technical Authority:
  - Signs final PP/CC assessment reports
  - Issues formal actions based on PP/CC reviews
  - In consultation with Administrator, adjudicates waiver requests to PP directive and standard.

## Director, SARD*

- Oversees execution of Agency-level SMA programs
  - Allocates funding from OSMA budget
  - Conducts programs reviews and assessments
- Maintains SMA NPDs, NPRs and standards

*Safety Assurance Requirements Division

## Planetary Protection Officer

•Coordinate with the PP Delegated Program activities;
•Develops standards, procedures, and guidelines
•Ensures P/p is appropriately implementing applicable PP requirements
•Ensures international obligations have been met and implications have been considered
•Certifies to the Chief S&MA flight missions have satisfied applicable PP requirements
•Participates in and leads international activities
•Advises OIIR and OGC on international policies
•Coordinates PPRE reviews

## Planetary Protection Research Delegated Program Manager

•Perform gap analysis to identify most critical areas of planetary protection (PP) to mitigate uncertainties and risks
•Perform research needed to improve methods to identify and reduce bioburden contamination
•Perform research needed to improve methods of testing and verification in support of PP requirements
•Identify new and emerging PP risks and uncertainties associated with human exploration missions relevant to PP
•Maintains technical standards on behalf of OSMA

# Category V Restricted Earth Return




- Previous requirements developed over decades of MSR preparation and adopted by COSPAR
- ESA and NASA are continuing a program of requirements refinement
- Key recommendations:

NRC: samples returned from Mars by spacecraft should be contained and treated as though potentially hazardous until proven otherwise

ESF: a Mars sample should be applied to Risk Group 4 (WHO) a priori

NRC: No uncontained martian materials ... should be returned to Earth unless sterilized

ESF: the probability of release of a potentially hazardous Mars particle shall be less than one in a million

# What Does 'Potentially Hazardous' Imply?



- Hazards must be either destroyed or contained
  - ➢ Contain samples or sterilize them, to ensure safety of Earth
- Must have sufficient confidence on containment
  - ➢ Requirements involve the probability of releasing a single particle of unsterilized material into the Earth environment
- Must have approved protocols for containment and testing
  - ➢ Review and update Draft Test Protocol using best available advice
  - ➢ Requirements on flight system contamination flow back from life detection protocols
- Technical requirements flow from the hazard assessment
  - – Impact on design and operation
  - – Impact on flight and ground system (C&C)
  - – Impact on hardware and software
  - – Impact on qualification and acceptance margins

# Guidelines for Restricted Earth Return



- "... the outbound leg of the mission shall meet Category IVb requirements..."
- "... the canister(s) holding the samples returned from [target] shall be closed, with an appropriate verification process, and the samples shall remain contained ... transport to a receiving facility ... opened under containment."
- "The mission and the spacecraft design must provide a method to "break the chain of contact" with [target]. ..."
- "Reviews and approval of the continuation of the flight mission shall be required ..."
- "For unsterilized samples returned to Earth, a program of life detection and biohazard testing, or a proven sterilization process, shall be undertaken as an absolute precondition for the controlled distribution of any portion of the sample."

All requirements are consistent with SSB recommendations from multiple reports on planetary protection considerations for Restricted Earth Return

# Earth Safety Analysis: Open Issues



- Statistical confidence needed to permit samples to be returned?
  - Policy guidance (SSB report and ESF study evaluated by COSPAR)
  - Technology development activities to assess/improve reliability of spacecraft systems are ongoing but relatively independent
- How confident are we that life can be detected, if there?
  - Statistical approaches needed to inform sub-sampling of returned samples, for both physical and biological heterogeneity
  - Instrumentation to make measurements that detect life
  - Field tests to demonstrate adequate performance
- What material will go to destructive testing for planetary protection?
  - Address only safety issues not covered by measurements useful to both science and planetary protection: *NOT a flat "10%"*
- What criteria allow release of unsterilized samples from containment?
  - A defined protocol for life detection, with appropriate decision trees for investigation branch-points, will inform policy: open-ended 'know it when we see it' approaches may be inadequate to permit release
  - Statistics of Risk Assessment/Decision Analysis will be key

# Early Policy Concerns Are Still Relevant

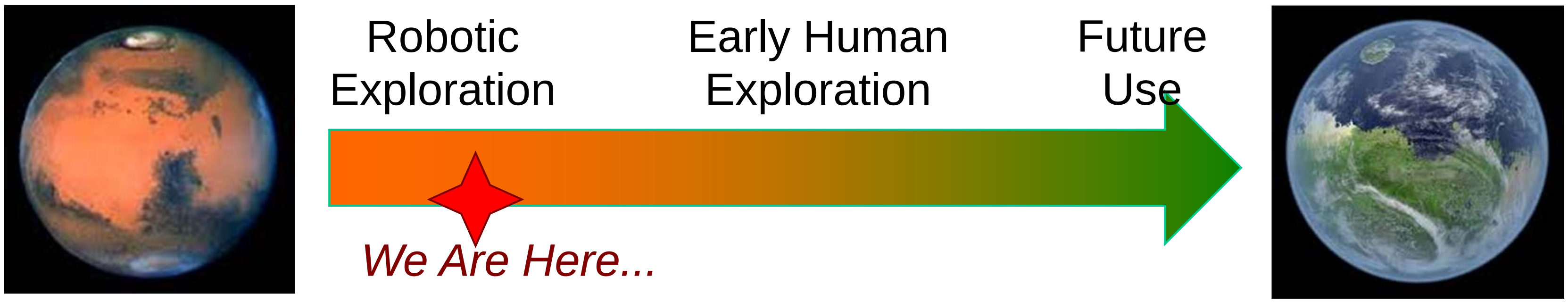


- We still don't know if there is native life on any other object in the solar system – but we do know that Earth life has been delivered to every object on which we've landed spacecraft.
- We don't know if possible extraterrestrial life might cause harm to the Earth, or astronauts – but we do know that Earth organisms, if introduced to the wrong places, will cause harm to human objectives.
- Indications of possible extraterrestrial life are not obvious, as we haven't found them with the few experiments that might detect something – but we have found indications of Earth contamination. This doesn't mean that extraterrestrial life is not present: just that we haven't been able to detect it yet.
- The worst way to detect extraterrestrial life is after it has been brought back to Earth and released, because we made incorrect assumptions on the basis of incomplete data.

# Future Concerns:
# Protecting Diverse Objectives at Mars



Can be consistent with scientific interests, but with more Earth contamination it becomes more difficult to detect Mars life...




**Phased Approach:** Be careful early; tailor later constraints to exploration or other goals, using knowledge gained on previous missions

- Humans have many interests at Mars; understanding potential hazards supports all of them
- Searching for Mars life or biohazards becomes more difficult because Earth contamination can overprint biosignatures and reduce signal-to-noise ratios
- Future colonization could be challenged, if unwanted Earth invasive species are introduced
  - Blocking aquifers
  - Consuming resources
  - Interfering with planned introductions

# Basic Motivation



Protect the Earth

Preserve Human Interests on Mars

**Human Exploration Systems**



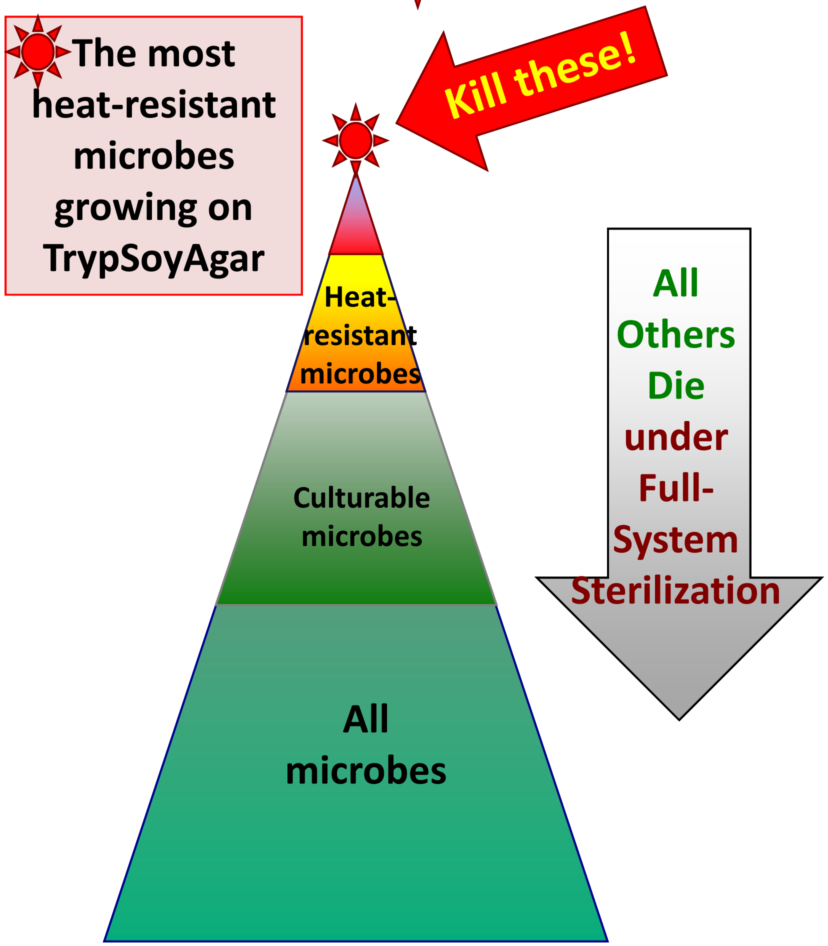
Understanding of facts informs future developments

# Questions?

# Options for Microbial Reduction



What is a "spore" for planetary protection?



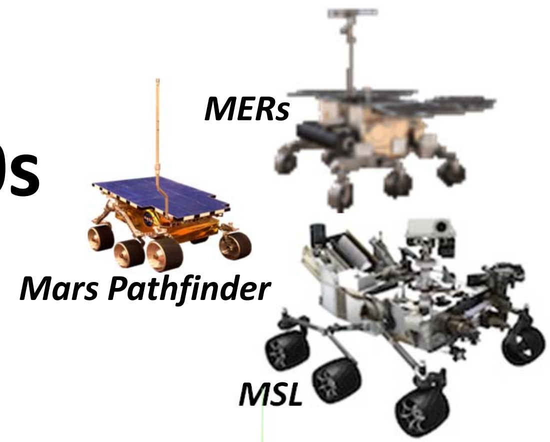

**Approximate Cost of Full-System DHMR: One Science Instrument**

## 1970s

Surface Cleaning
Full-System Heat Reduction
Bioshield during Launch
*Organic Cleanliness and Overpressure*
*Recontamination Prevention for MS*


## 1990-2010s

Surface Cleaning




## 2000s

Surface Cleaning
Subsystem Reduction
Biobarrier for Arm