



Mars Exploration Rover

Planetary Protection and it's application to the Mars Exploration Rover (MER) Project*

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- **Introduction to planetary protection (PP)**
 - Purpose of planetary protection
 - Origin of planetary protection
 - How NASA PP requirements are determined
 - Mission PP categories
- **MER Planetary Protection**
 - Spacecraft configuration
 - PP requirements
 - Summary of implementation
 - Status of compliance



Purpose of Planetary Protection



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- **Protect the future exploration of other solar system bodies for life, remnants of past life, and the precursors of life (forward contamination)**
- **Protect the Earth from possible hazards of returned extraterrestrial material (back contamination)**



Courtesy of JPL/Caltech



Origin of Planetary Protection



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- **1958: Council of U.S. National Academy of Sciences (NAS)**
 - NAS calling for the conduct of planetary exploration in a fashion that “prevents contamination of celestial objects”
- **1959: NASA adopts first policy**
 - Calling for “payloads which might impact a celestial body [to] be sterilized before launching”
- **1964: Committee on Space Research (COSPAR) resolution**
 - Probability 10^{-4} or less for viable organism on lander or probe (anywhere!) and accidental impact by unsterilized flyby or orbiter $<3 \times 10^{-5}$
- **1966: COSPAR resolution**
 - 10^{-3} limit of total probability of contamination of a “planet” by all missions during period of biological exploration
- **1967: International treaty signed by U.S.**
 - “Moon Treaty”: “States parties to the treaty shall pursue studies of outer space... so as to avoid their harmful contamination and also adverse changes in the environment of the Earth”
- **1967: NASA PP policy adopting COSPAR 1966**
 - NASA first version of 8020.7 and 8020.12
- **1981: NASA PP policy undergoes major revision**
 - Drafted in 1981, not formalized until 1999
- **2002: COSPAR Planetary Protection Policy adopted**
 - Addressed Europa exploration and added concept of “special regions” for Mars
 - Introduced some new language about PP requirements for Mars life detection missions



Project-Specific PP Requirements: Exceptions and Basis



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- **PP does NOT apply to**
 - **Earth-orbiting missions**
 - **Lunar missions**
 - **Crewed missions (Except does apply to robotic missions launched by crewed systems)**
- **Requirements per PP category of the Project**
 - **Based on type of mission and “planets” encountered or targeted**
 - **Covers intentional and unintentional deposition of Earth organisms on other solar system**
 - **Must consider any “planet” encountered, whether a target of the mission or not**
 - **Includes JPL instruments on non-JPL or non-U.S. missions**
 - **Subject to NASA Planetary Protection Officer (PPO) approval**
 - **PPO sets the category**

***”Planet” means any solar system body: planets, planetary satellites, comets, asteroids, etc.**



Project-Specific PP Requirements: Mission PP Category



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- **Category I: Any mission type to Sun or Mercury**
 - No biological interest
- **Category II: Any mission type to Venus, Jupiter, Saturn, Uranus, Neptune, Pluto, outer planet satellites (except Europa), comets, asteroids**
 - Intermediate biological interest
- **Category III: Fly-by or orbiters to Mars, Europa**
 - High biological interest



Project-Specific PP Requirements: Mission PP Category (cont.)



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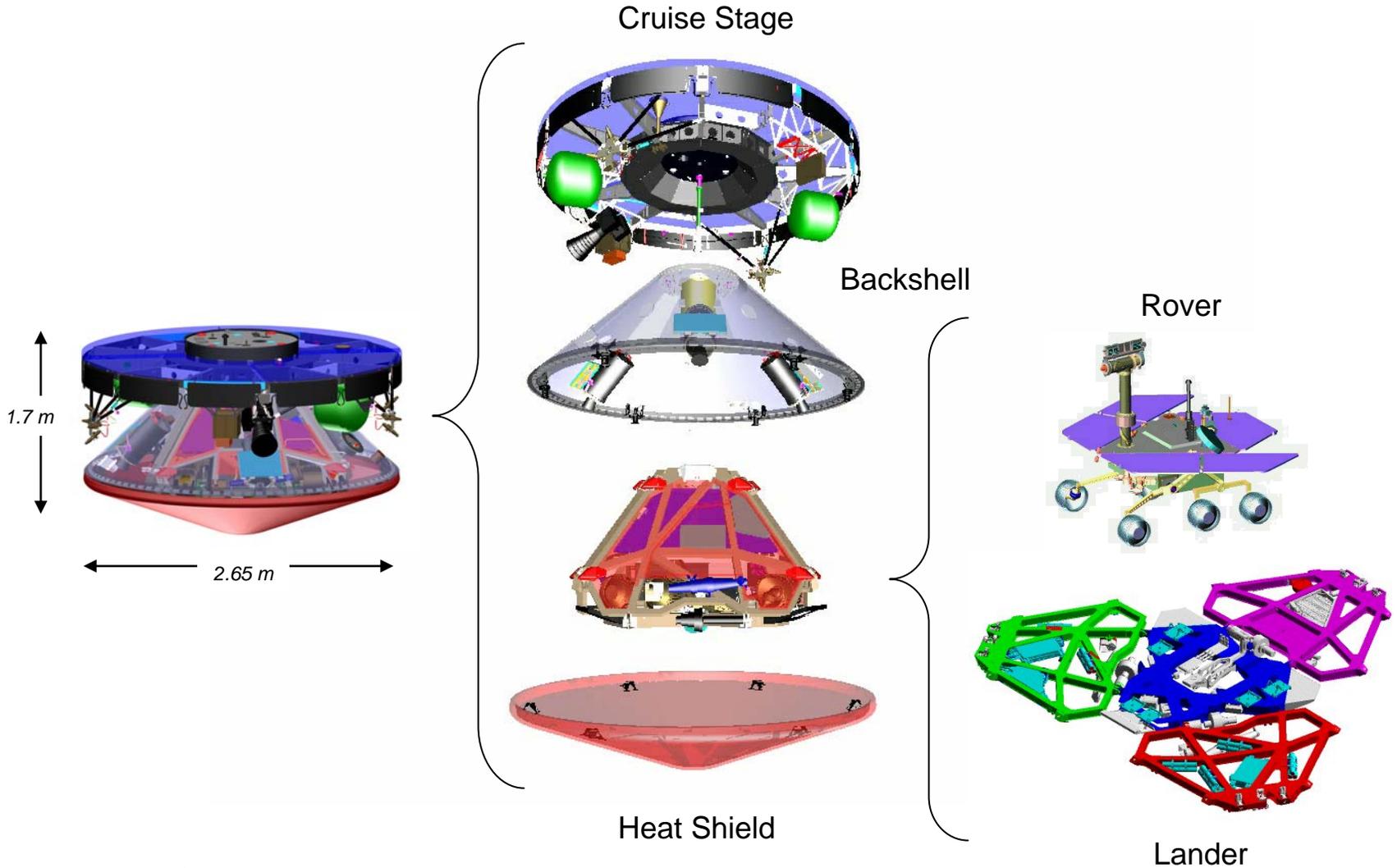
- **Category IV: Lander or probe to Mars, Europa**
 - **Cat. IV-A: Without life-detection experiments**
 - **Cat. IV-B: With life-detection experiments**
 - **Cat. IV-C: Without life-detection experiments but accessing “special regions” (likely to contain water) through horizontal or vertical mobility**
- **Category V: Earth return from any extraterrestrial solar system body**
 - **“Restricted Earth return”**
 - **“Unrestricted Earth return”**



MER Spacecraft Configuration



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Courtesy of JPL/Caltech



MER Planetary Protection Requirements



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- **PP Category IV-A (MER Planetary Protection Plan):**
 - **Documentation**
 - **Probability of impact of Mars by the launch vehicle (or any stage thereof) shall not exceed 0.0001**
 - **Probability of accidental impact of Mars due to failure during cruise phase shall not exceed 0.01**
 - **Spacecraft assembled in Class 100,000 clean facilities or better, with appropriate controls and procedures**
 - **Bioburden:**
 - **Total exposed surface bioburden of the landed hardware shall not exceed 300,000 viable aerobic spores at launch**
 - **Total (all surfaces, including mated, and in the bulk of non-metals) bioburden at launch of hardware for which a hard impact is planned shall not exceed 500,000 viable aerobic spores minus bioburden allocated to landed hardware (negotiated resolution, MPF precedent)**
 - **Average exposed surface bioburden of the landed hardware shall not exceed 300 viable aerobic spores/m² at launch**
 - **Organic materials:**
 - **List of organic materials and masses**
 - **50 g sample of any organic material of 25 kg or more is used**



MER Planetary Protection Summary of Implementation



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- **Implementation Plan**

<u>Hardware By Approach</u>	<u>Fraction of Total Items*(No. of Items)</u>
Dry Heat Microbial Reduction**	48% (349)
IPA Wipe / Rinse Only	35% (249)
WEB Exempt/ HEPA Isolation	12% (83)
Other	6% (40)

* Percentages based on number of line items, not surface area or bioburden allocation

** Includes Non-standard DHMR & entry sterilization



MER Planetary Protection Status of Compliance



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- **Estimated Bioburden at Launch* versus the Spore Burden Requirements**
 - **Landed Hardware - Lander, rover, and parts of aeroshell and of EDL subsystem that are exposed even without impacting Mars**
 - **Impacting Hardware - Most of aeroshell, BIP, and backshell-mounted equipment (includes an allowance for part of cruise stage)**
 - **Cruise stage (no requirement, values for source to backshell only)**

	MER-2 / MER-A		MER-1 / MER-B	
	Worst Case Spore Surface Density, spores/m ²	Worst Case spores	Worst Case Spore Surface Density, spores/m ²	Worst Case spores
LANDING HARDWARE	74	101000	74	209000
Requirement	300	300000	300	300000
IMPACTING HARDWARE	68	119000**	68	69000**
Requirement	n/a	200000	n/a	200000
CRUISE STAGE	350	n/a	750	n/a

* 3 sigma worst case

** Includes mated and encapsulated (in volumes) spores also



MER Planetary Protection Status of Compliance



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- **Probability of impact of Mars by the launch vehicle (< 0.0001 required)**
 - MER-A probability of impact < 0.00002
 - MER-B probability of impact < 0.00004
- **Probability of accidental impact of Mars due to failure during cruise phase (< 0.01 required)**
 - MER-A at launch window open (5/30/03)* probability of impact = **0.00928**
 - MER-A post launch (6/10/03) probability of impact = **0.00786**
 - MER-B at launch window open (6/25/03) probability of impact = **0.00895**
 - MER-B post launch (7/8/03) probability of impact = **0.00771**

* MER-A launch is not before 6/08/03