Planetary Protection Provisions for Mars: Forward & Back Considerations

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Various Roles in Planetary Protection

- **Establish policy** for planetary protection, establish mission-specific requirements, and verify compliance (PPO)
- Plan and implement to **achieve compliance** with mission specific PP requirements (Projects, with Program investment)
- Plan strategically for **future needs** (All)
  - **Policy development**—through COSPAR in the international arena and by NASA in the domestic arena
  - **Technology development**—identify, develop, and test new technologies for use to meet the PP needs of flight projects, enabling missions to biologically interesting targets
  - **Facilities needs**—laboratories to support R&D and implementation, including sample receiving facilities and archive facilities

Planetary protection is a "way of life" in solar system exploration.

Exciting Directions and New Challenges

- **Recent discoveries:** Science data about tough microbes on Earth and a significant potential for martian habitable areas: to be investigated by future *in situ* exploration missions.
- **Policy effects:** Scientific discoveries are leading to updated implementation requirements to comply with planetary protection policies, including a new planetary protection category for Mars missions, and a "real-soon-now" updated set of recommendations from the National Research Council.
- **Mars Sample Return on the horizon:** MSR adds back contamination requirements to the existing forward contamination requirements, including strict containment and biosafety analysis in a Sample Receiving Facility.
- **Human missions to Mars:** What do we know, what can we know, and when do we need to know it? Placing humans safely on Mars and bringing them back to Earth will require new knowledge, and a meaningful extension of current planetary protection policy and its requirements.

PP Categories for Mars Landed Missions
w/Current Representative Requirements

Cat IV: Lander or probe to Mars, a planet of significant interest

Cat V: Earth return

IVa

- No extant life detection experiments
- Bioburden reduction required
- Clean to average of <300 cultivable aerobic spores/sq meter*
- Verify by bioassay

IVb

- Extant life detection experiments
- Bioburden reduction required
- Verify pre-sterilization cleanliness by bioassay
- Surface sterilization required
- Bioshield to prevent recontamination

IVc

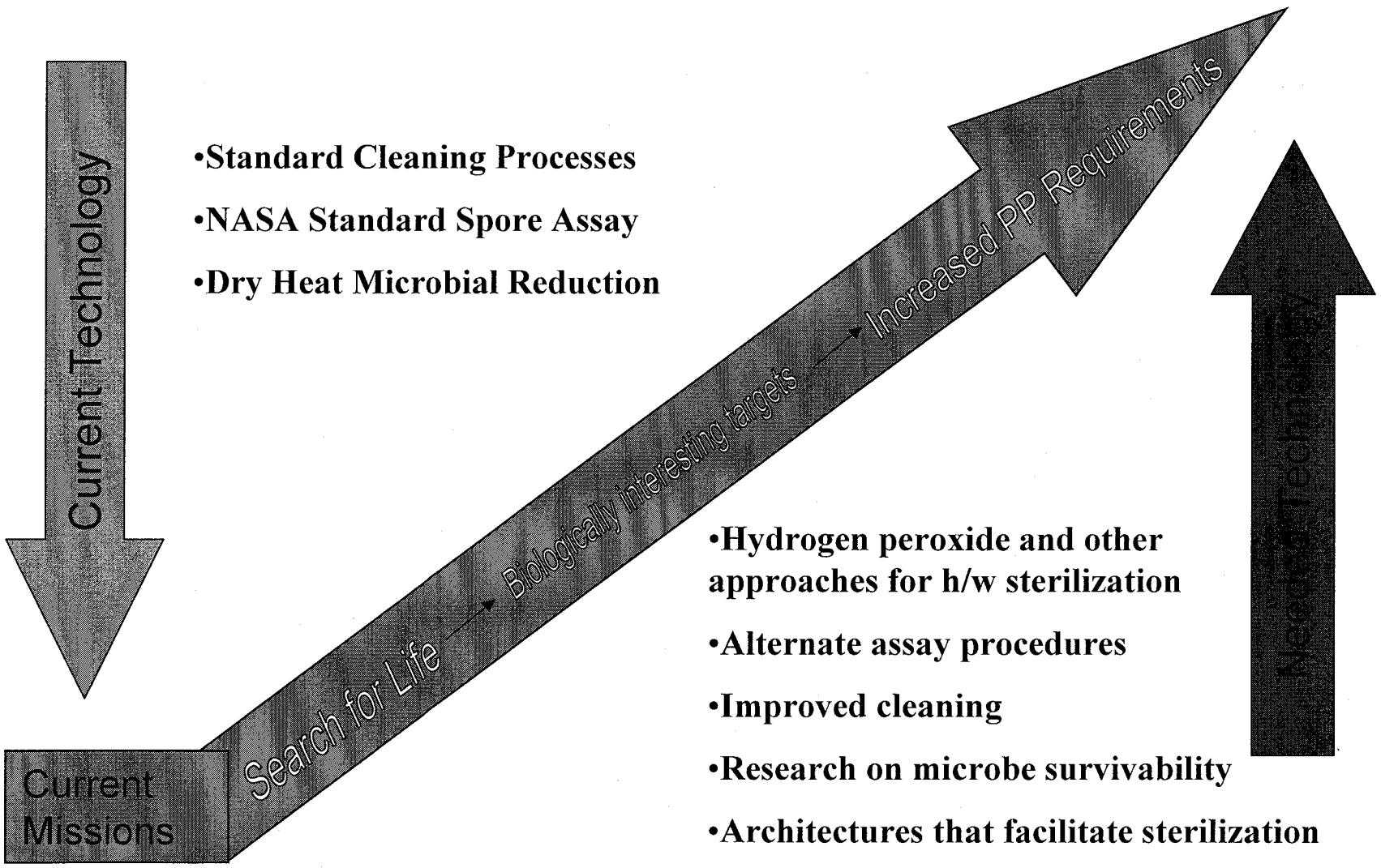
- Investigate martian special regions
- Not driven by life detection experiments
- Bioburden reduction required
- Range of implementation options (system vs subsystem; surface vs bulk)
- Bioshield

V

- Stringent measures to prohibit unplanned Earth impact
- Returned hardware sterile
- Containment of any sample
- Microbial reduction
- Microbial assay
- Microbial archive
- Sample quarantine and assessment (sample receiving facility)

***<300 cultivable aerobic spores/m^2 ≈ <300,000 viable organisms/m^2 of all types**

New PP Technology Needs

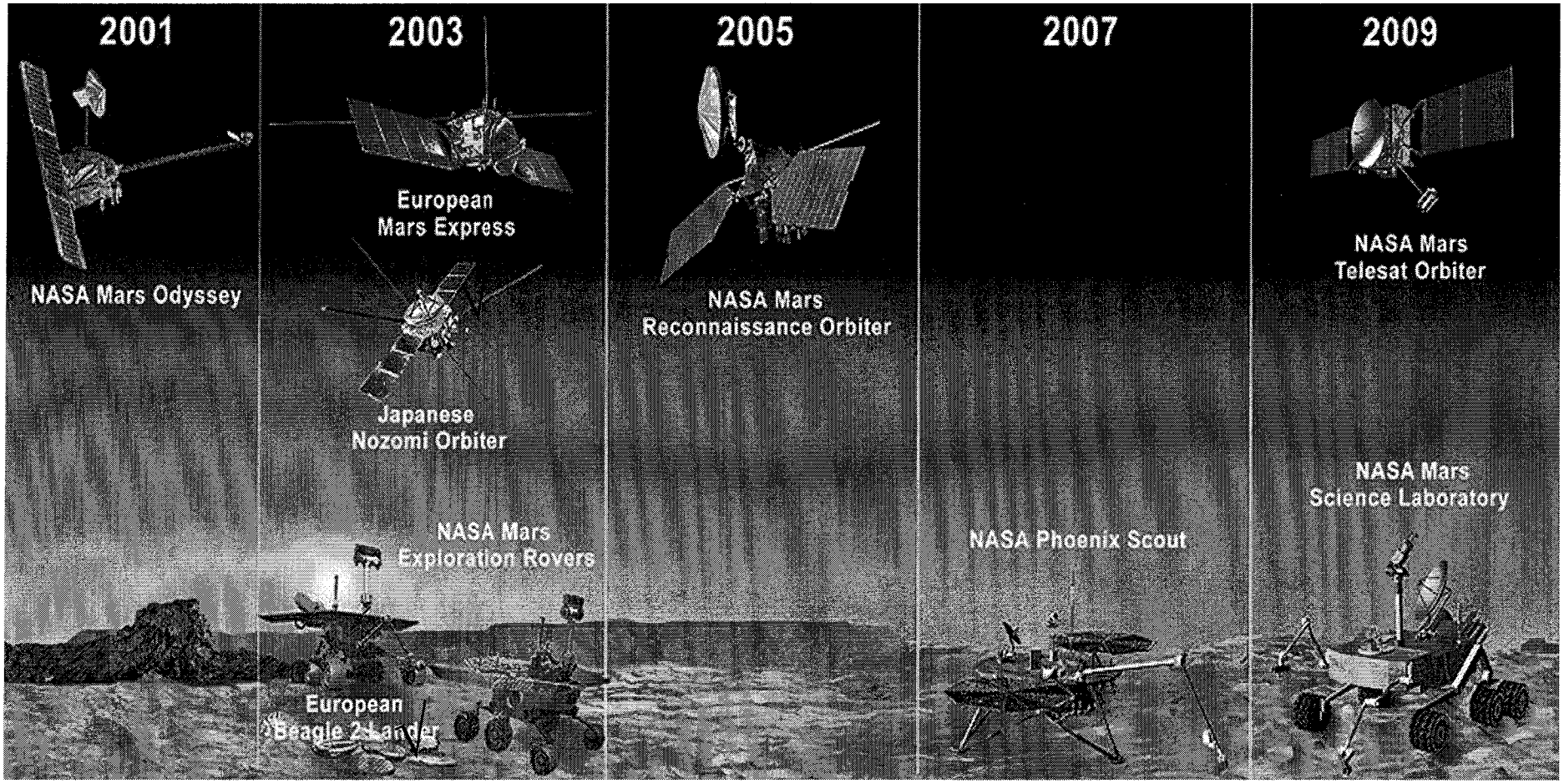


- Standard Cleaning Processes
- NASA Standard Spore Assay
- Dry Heat Microbial Reduction

- Hydrogen peroxide and other approaches for h/w sterilization
- Alternate assay procedures
- Improved cleaning
- Research on microbe survivability
- Architectures that facilitate sterilization
- Sample containment and Earth return

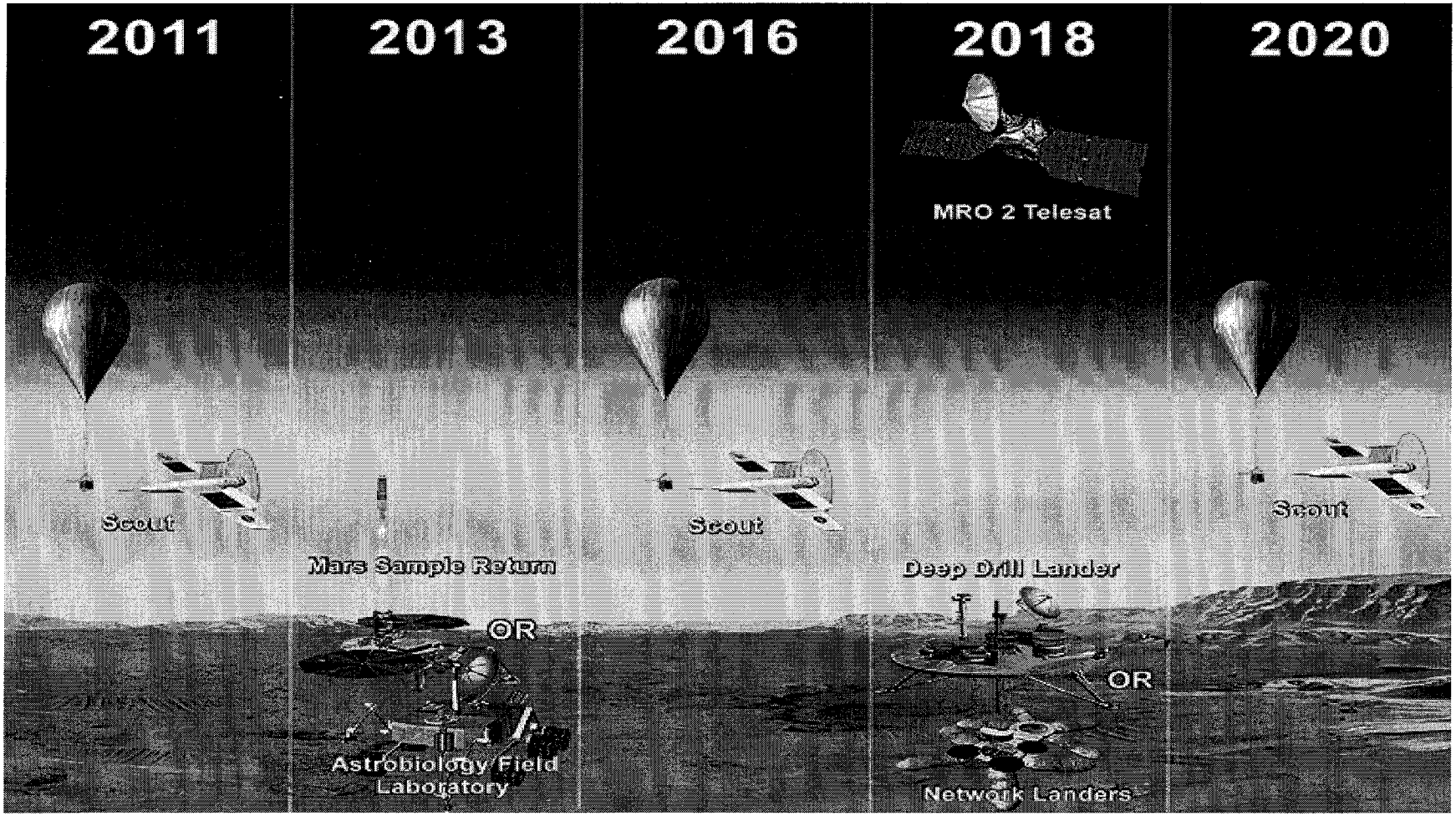
Mars Exploration Pathway

This Decade (planned)



Mars Exploration Pathway

Next Decade (TBD)



PP Challenges for Current Missions

- **Phoenix – 2007 Launch**
  - First US mission required to comply with intent of new COSPAR Category IVc
  - Plans to implement Viking-level sterilization of the hardware used to access (and touch) the martian subsurface
  - Challenges include hardware sterilization, maintenance of sterility using a biobarrier, deployment outside of the biobarrier at Mars, prevention of recontamination of sterile hardware during operations

- **Mars Science Laboratory (MSL) – 2009 Launch**
  - Planning to achieve unprecedented levels of organic cleanliness
  - Must be responsive to concerns about martian special regions, if targeted
  - Nuclear power system, if used, may raise additional complexities
  - Challenges include reaching organic cleanliness goals and addressing issues of such as a landing mishap for possible nuclear mission.
  - MSL is currently developing its planetary protection implementation strategy, to take into account selected science payload and intended landing site

PP Technologies for Mars Missions

Prelaunch/Operations Technologies

- Cleaning to sterility (JPL)
- Assays for rapid assessment of cleanliness—cultivable, non-cultivable, molecular
- Particle transport models
- Development of Mars orbital debris analysis code
- Aseptic assembly systems
- Vapor hydrogen peroxide and/or radiation sterilization of assembled subsystem

Launched Hardware

- Lightweight biobarriers for forward-contamination prevention
- *In situ* sterilization systems
- Container sealing systems
- Mechanism or series of mechanisms for "break-the-chain" of contact
- Earth targeting improvements
- Earth entry vehicle for assured containment
- Meteoroid protection on spacecraft

Sample Handling Systems

- Multi-directional containment systems for sample handling
- Systems for analysis of contained samples (Sample Receiving Facility)

Research Required to Inform the Development of Technologies

- Fundamental biology of survivability (microbial characterization in flight hardware manufacturing environments)
- Advanced spacecraft designs to provide for sterilization and aseptic assembly
- Materials screening to enable system/subsystem sterilization

Summary

- Exploration of biologically interesting planets such as Mars (Europa, too) requires increased levels of capability in planetary protection.
- These capabilities require a technology program focused on the broad challenges of planetary protection. Plans for forward and backward contamination control, returned sample handling, and the related area of organic contamination control have been formulated and are underway.
- The endeavor is inherently multidisciplinary, and requires the creative efforts of policy makers, planetary scientists, technologists, and systems engineers – as well as biologists.
- NASA and its international partners are actively engaged in planetary protection implementations for current missions, and in preparation for the very exciting missions of the future.