Finding and Removing Microbes from Spacecraft

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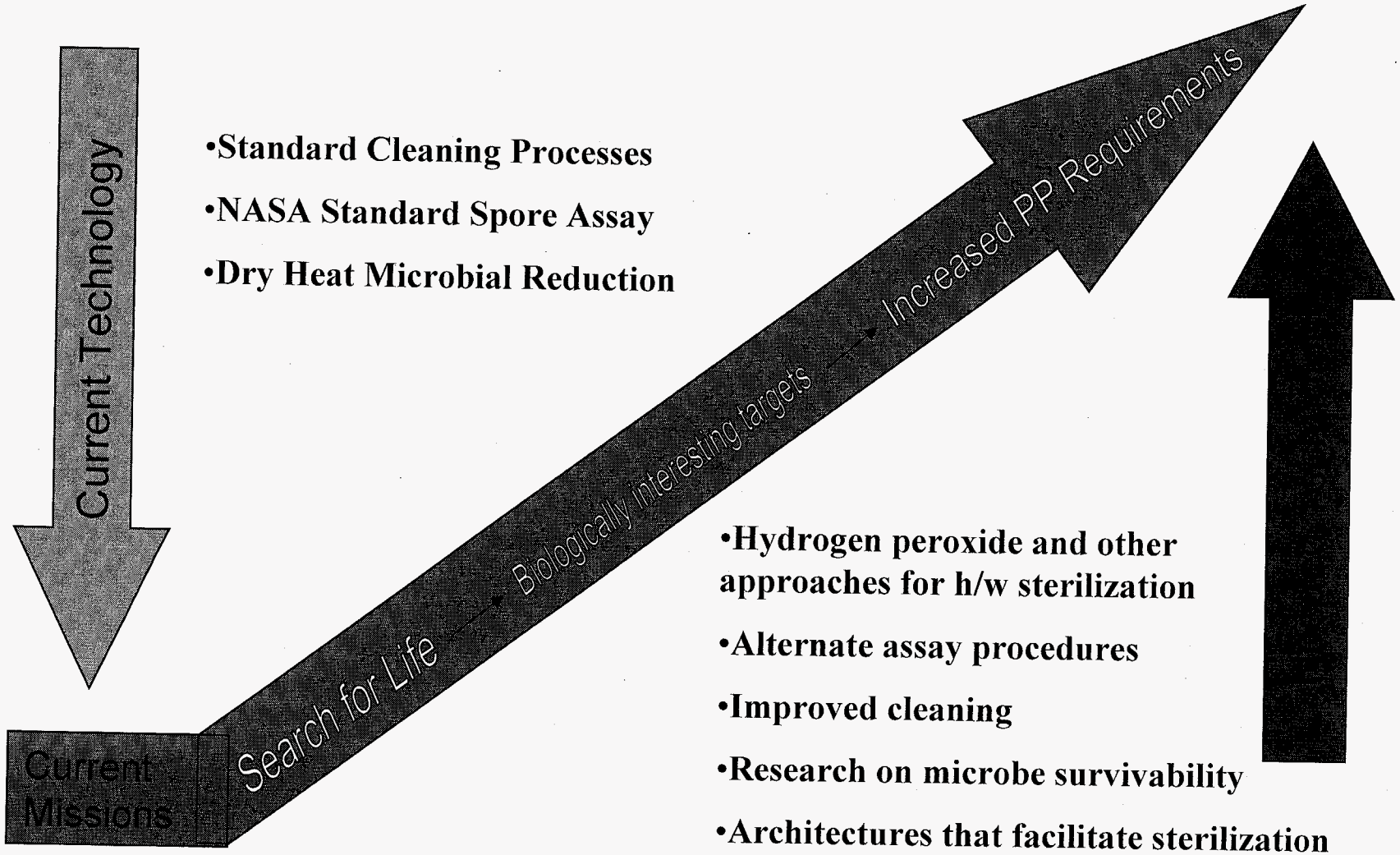
IEEE Aerospace Conference, Big Sky, Montana
March 8, 2005

Search for Life Drives PP Technology



- 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

PP Practices from Viking to MER

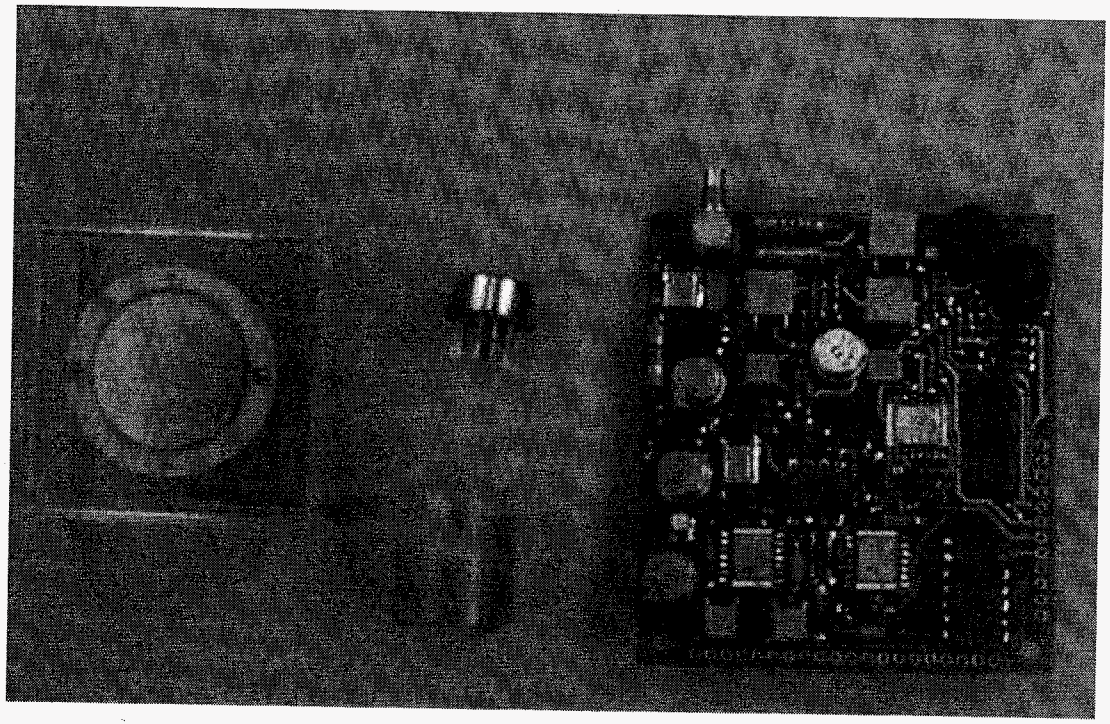
- Cleaned with standard aerospace methods
  - Precision Cleaning
  - Alcohol and clean-room wipe
- Assessed for "bioburden" based on sample collection with a cotton swab and enumeration of cultivable spore formers on petri dish as described in the NASA Standard Procedures for the Microbiological Examination of Space Hardware NHB 5340.1A (1968)
- "Sterilized" by dry heat microbial reduction
  - System sterilization (Viking) or selected subsystems (all others)
  - Typically in range 110C to 125C
  - For 50 to 5 hours for surfaces (longer for bulk)

Recommendations for Change

- In *Biological Contamination of Mars: Issues and Recommendations* the Space Studies Board of the National Research Council (1992) recommended:
  - That future Mars landers be cleaned per Viking, with or without the "sterilization" step; but that
  - Efforts should be made to adopt current molecular analytical methods for use in bioburden assessment and inventory procedures for spacecraft assembly and launch for future mission, and also develop new methods for the same purposes
- Expanded recommendations along these lines anticipated in the 2005 update to the 1992 SSB/NRC report

New Spacecraft Materials, New Challenges

- Modern materials and sophisticated electronics and sensors in today's spacecraft create the need for new cleaning and sterilization technologies
  - Metals
  - Plastics
  - Adhesives
  - Tapes
  - Lubricants
  - Circuit board coatings
  - Coating/Paints
  - Composites
  - Thermal blankets
  - Microelectronics

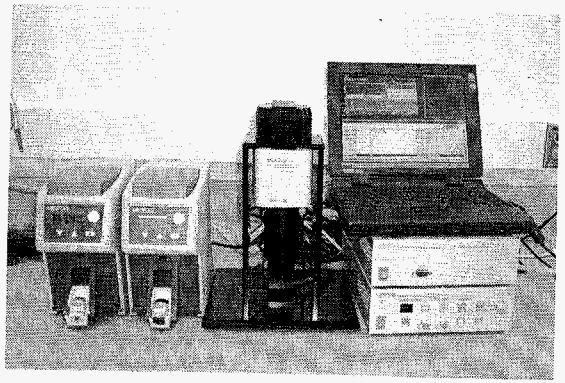


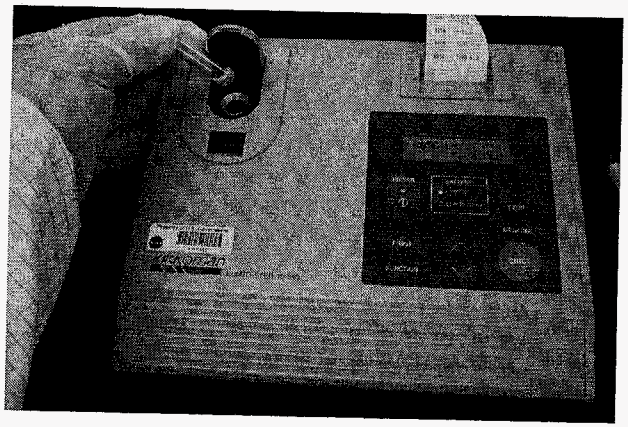
Cleaning Methods / Studies

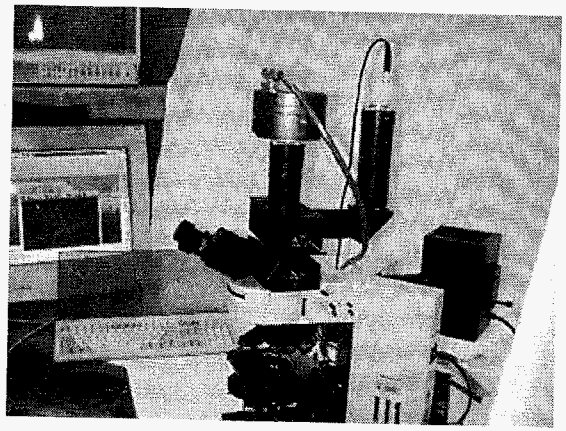
- Disinfection
  - None, UV, hydrogen peroxide, autoclave
- Solvents
  - IPA-HPLC, IPA-SC, IPA-RG, Ethanol (200 proof)
  - at Varied Concentrations
    - 30%, 50%, 70%, 100%
- Wipes
  - Coventry, Alpha 1009, Technicloth, Scourwipe
- Rinses
  - None, Sigma water, IPA-RG, Ethanol

Microbial Burden Detection Technologies

- NASA bioburden assay (viable/cultivable)
- Epifluorescence microscopy (whole cell)
- Enzyme-based assay (molecular method, general bioassays)
  - Total adenosine triphosphate (T-ATP)
  - Limulus amebocyte lysate (LAL)
- Detection of spore bio-signature molecules
  - Dipicolinic acid (DPA) (spores)

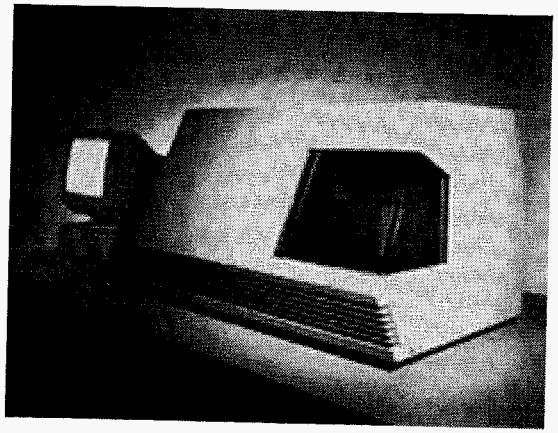


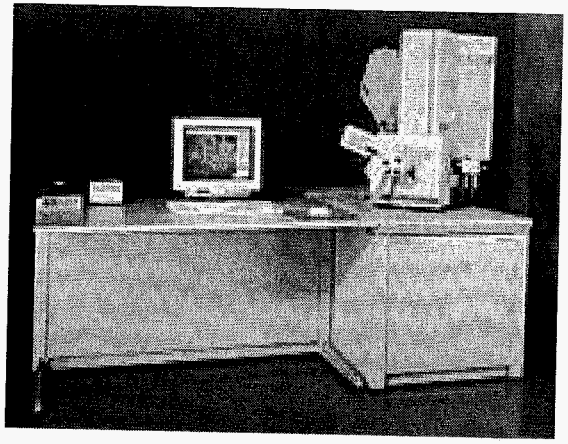


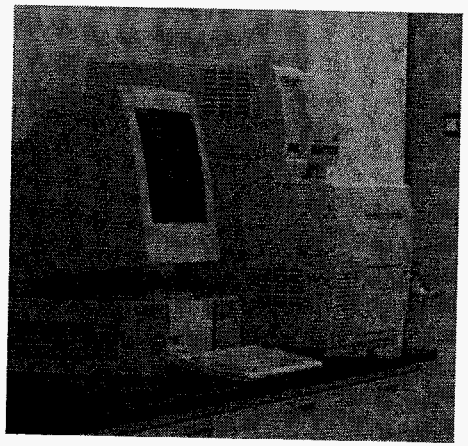


Microbial Burden Detection Technologies

- Polymerase Chain Reaction (DNA)
  - Qualitative and quantitative PCR
- Gas chromatography/MS (Lipid, Protein)
  - HPLC, FPLC
- Capillary electrophoresis (Protein, Sugars)
- Others (FTIR, MALDI-TOF, ESEM, Confocal microscopy, UV-Raman)

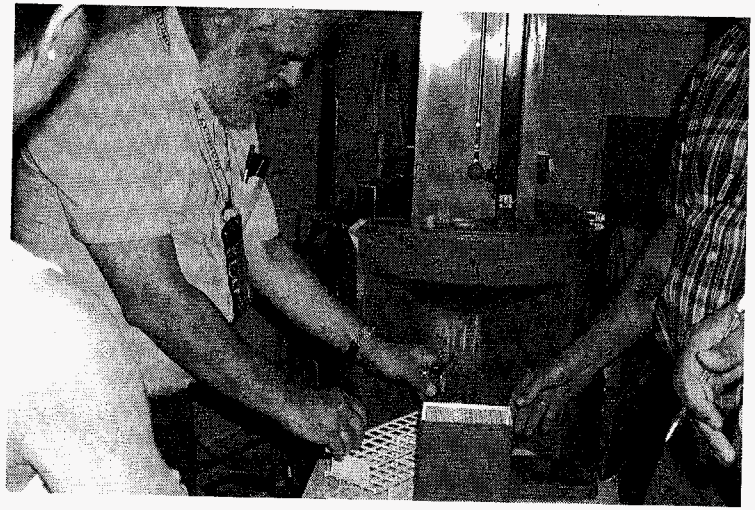


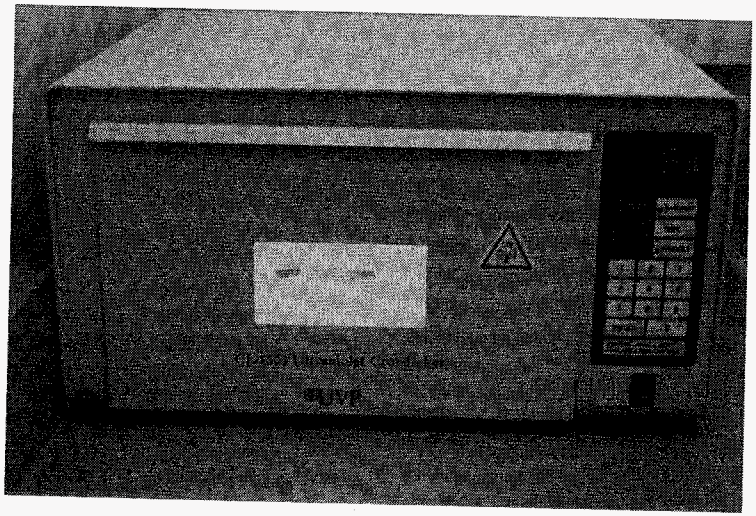


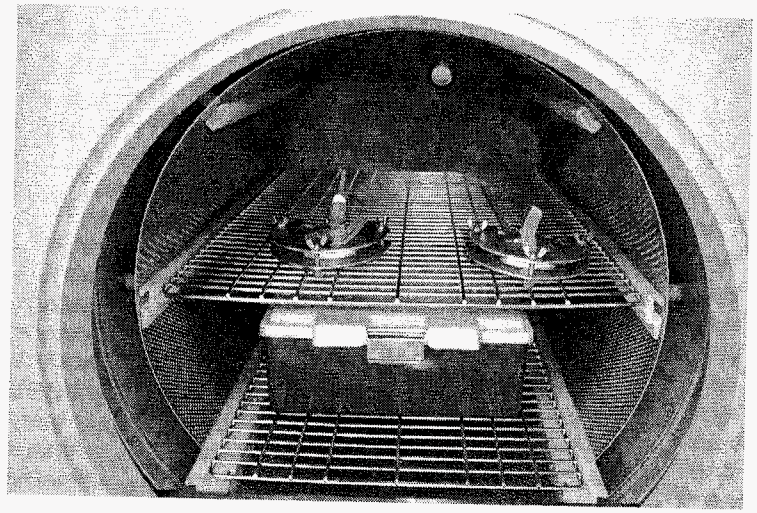


Relevant Sterilization Technologies

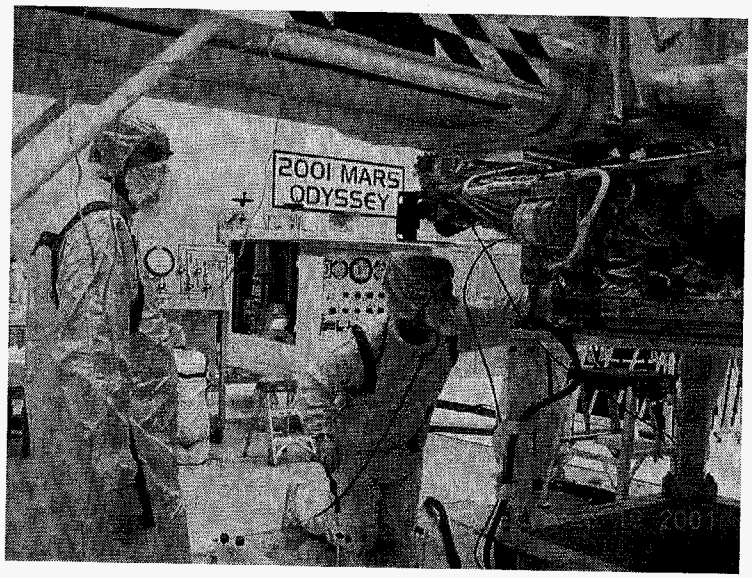
- Hydrogen peroxide vapor
- Ultraviolet light
- γ-radiation
- Dry-heat
- Pulsed-light

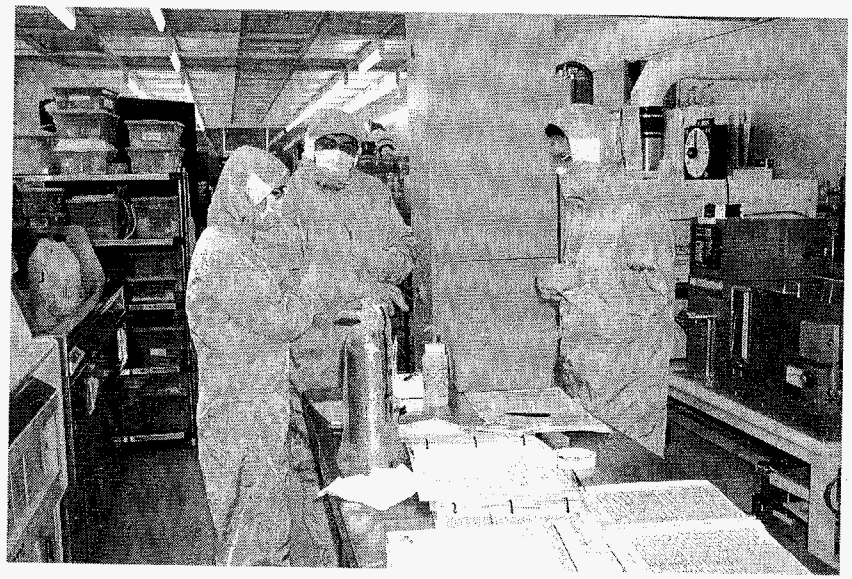


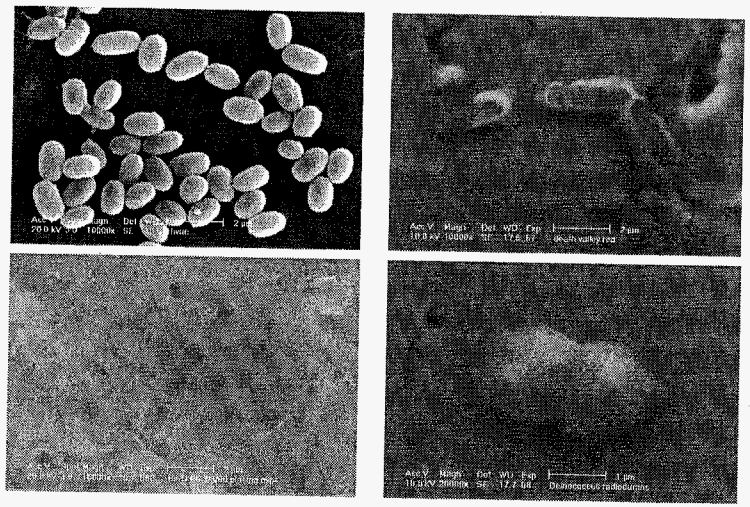




Microbes Associated with Spacecraft







- Catalogue microbial species
- Identify sterilization resistances
- Determine background level of contamination in spacecraft assembly areas

Summary