

National Aeronautics and Space Administration



Mars Sample Return Receiving Facility

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www.nasa.gov

NASA Planetary Protection Policy Protects Science on Mars

- “The conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized.”
 - Preserves science opportunities directly related to the NASA Vision, and can support certain ethical considerations; originally recommended to NASA by the NAS in 1958
 - Preserves our investment in space exploration
 - Can preserve future habitability options

Planetary Protection Policy Protects Earth and Comes Before Planetary Science for Sample Return

- “The Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from another planet.”
 - Preserves the Earth’s biosphere, upon which we all depend...
- *A central tenet MUST be a presumption of ignorance:* It isn’t that we expect to find life out there—it’s that we never expected to find what we have here....
 - Abundant life at deep-sea hydrothermal vents was discovered in 1977, 7 months *after* Viking first landed on Mars

The Outer Space Treaty

- Signed by the US and Soviet Union in January 1967 and Ratified by the Senate on Apr. 25th, 1967
- Article IX:
“...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...”

“Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.” (<http://www.state.gov/t/ac/trt/5181.htm>)

NASA Planetary Protection Policy

- Policy embodied in NPD 8020.7F (*NASA Administrator*)
 - Planetary Protection Officer acts on behalf of the AA 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 which also considers international policies
- Specific requirements for robotic missions embodied in NPR 8020.12C (*AA, SMD*)
 - Encompasses all documentation and implementation requirements for forward and back-contamination control

Committee on Space Research (COSPAR) Planetary Protection Policy

- COSPAR sets international policies and implementation guidelines.
- COSPAR policy is that all samples returned from Mars be category V restricted Earth return
 - **Requires containment at the highest level**
 - “Although the existence of life elsewhere in the solar system may be unlikely, 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 space–craft returning from another planet. Therefore, for certain space mission/target planet combinations, controls on contamination shall be imposed, in accordance with issuances implementing this policy.”
(DeVincenzi et al. 1983)



Natural Sample “Return”: ALH84001



- Multiple observations were argued to indicate the presence of Martian life, however subsequent research does not support that hypothesis
- Pristine samples returned from Mars will need to avoid heating that can destroy scientific integrity and contamination control for planetary protection

Category V Requirements for Mars

The Earth-return mission is classified "Restricted Earth return" and is subject to the following requirements:

1. Unless specifically exempted, the outbound leg of the mission shall meet Category IVb requirements. This provision is intended to avoid "false positive" indications in a life-detection and hazard-determination protocol or in the search for life in the sample after it is returned. A "false positive" could prevent distribution of the sample from containment and could lead to unnecessary increased rigor in the requirements for all subsequent Mars missions.

Category V Requirements for Mars

2. Unless the sample to be returned is subjected to an accepted and approved sterilization process, the sample container must be sealed after sample acquisition. A redundant, fail-safe containment procedure with a method for verification of its operation before Earth-return shall be required. For unsterilized samples, the integrity of the flight containment system shall be maintained until the sample is transferred to containment in an appropriate receiving facility.

Cat. V Requirements for Mars

3. The mission and the spacecraft design must provide a method to "**break the chain of contact**" with Mars. No uncontained hardware that contacted Mars, directly or indirectly, shall be returned to Earth. Isolation of such hardware from the Mars environment shall be provided during sample container loading into the containment system, launch from Mars, and any in-flight transfer operations required by the mission.

Cat. V Requirements for Mars

4. Reviews and approval of the continuation of the flight mission shall be required at three stages:

- 1) prior to launch from Earth;
- 2) prior to leaving Mars for return to Earth;
- 3) prior to commitment to Earth entry.

Cat. V Requirements for Mars

5. 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.

Draft Test Protocol for Biohazard Detection

NASA/CP—2002-211842



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

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October 2002

- Developed during a series of five workshops over several years
- Oversight and review committee chaired by the late Dr. Joshua Lederberg
- Includes consideration of
 - Containment
 - “Sterilization”
 - Physical/Chemical Processing
 - Life Detection Testing
 - Biohazard Testing
 - Facility Requirements
 - Environmental and Health Monitoring
 - Personnel Management
 - Contingencies
 - Protocol Maintenance/Updates

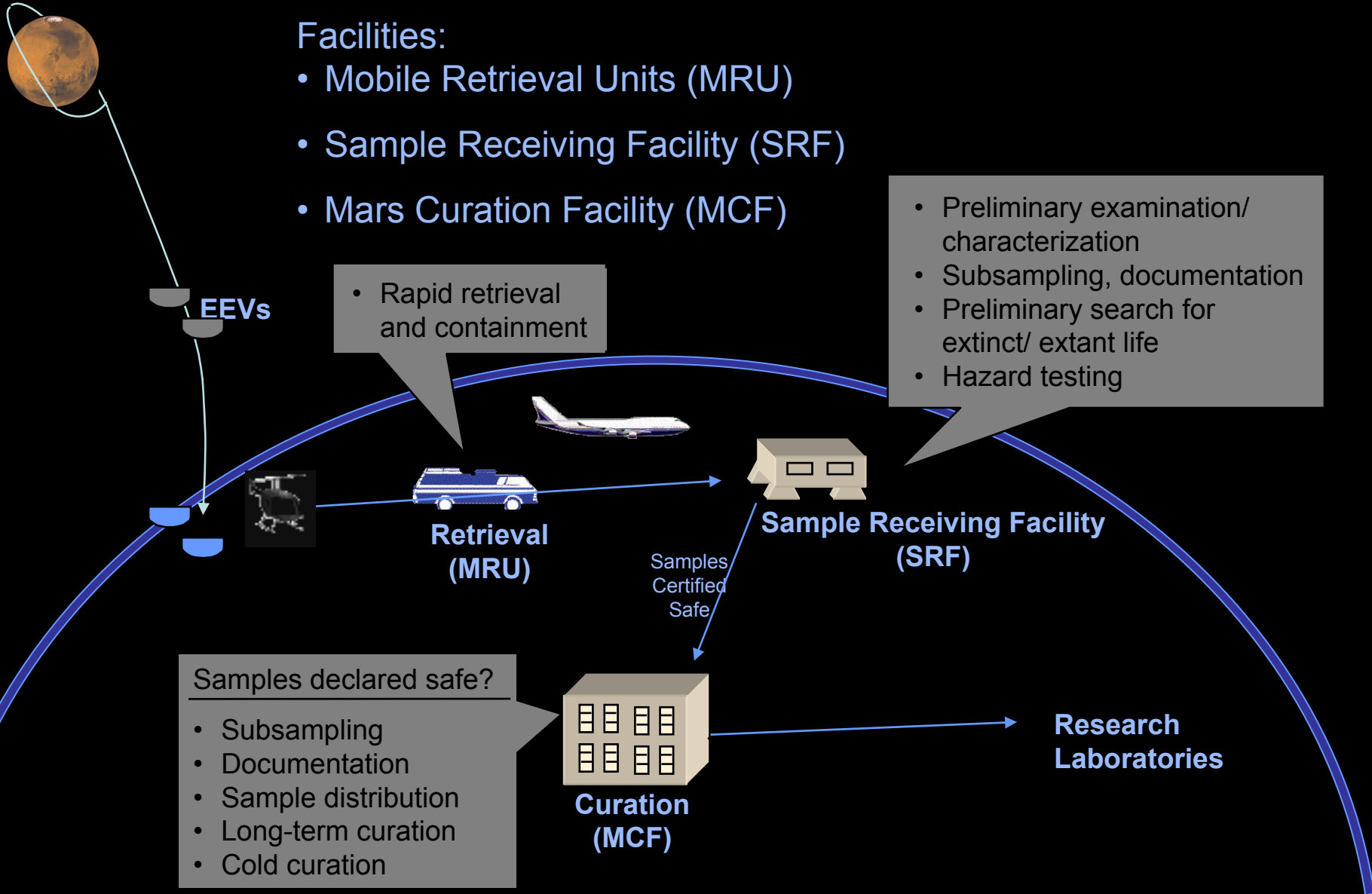
Mars Sample Return Containment Facility

- The 2002 "*Draft protocol for detecting possible biohazards in Martian samples returned to Earth*" should be updated to take into account new knowledge and techniques derived from post 2001 research on biohazards and microbiology.
- The protocol should revisit practical requirements for mission planning: factors such as mass of sample needed to evaluate biohazards, length of time for quarantine, verifiable limits to containment, and specific criteria necessary to permit release of samples.

Planetary Protection: Preventing Backward Contamination:

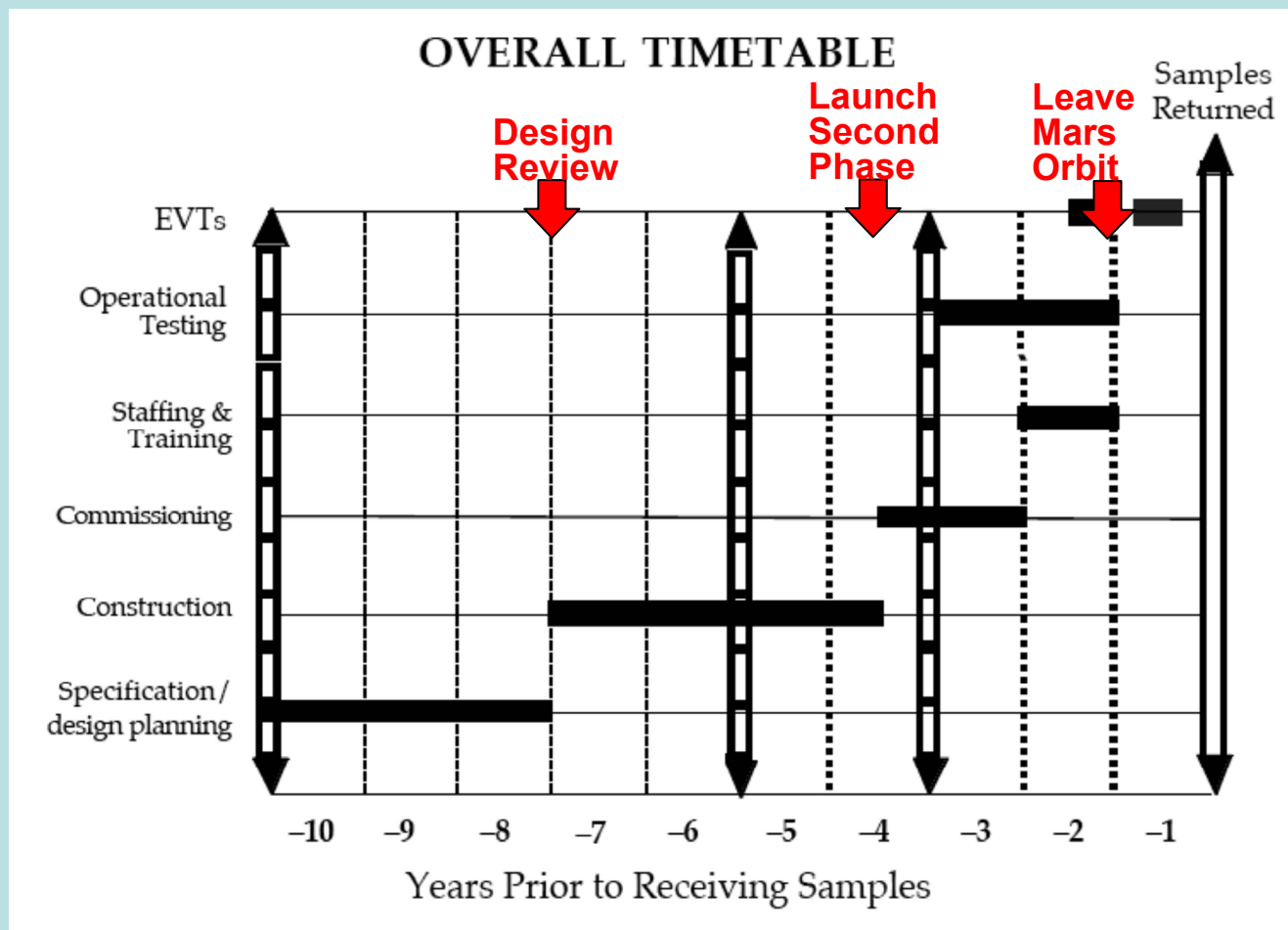
Facilities:

- Mobile Retrieval Units (MRU)
- Sample Receiving Facility (SRF)
- Mars Curation Facility (MCF)



Sample Receiving Facility Timeline

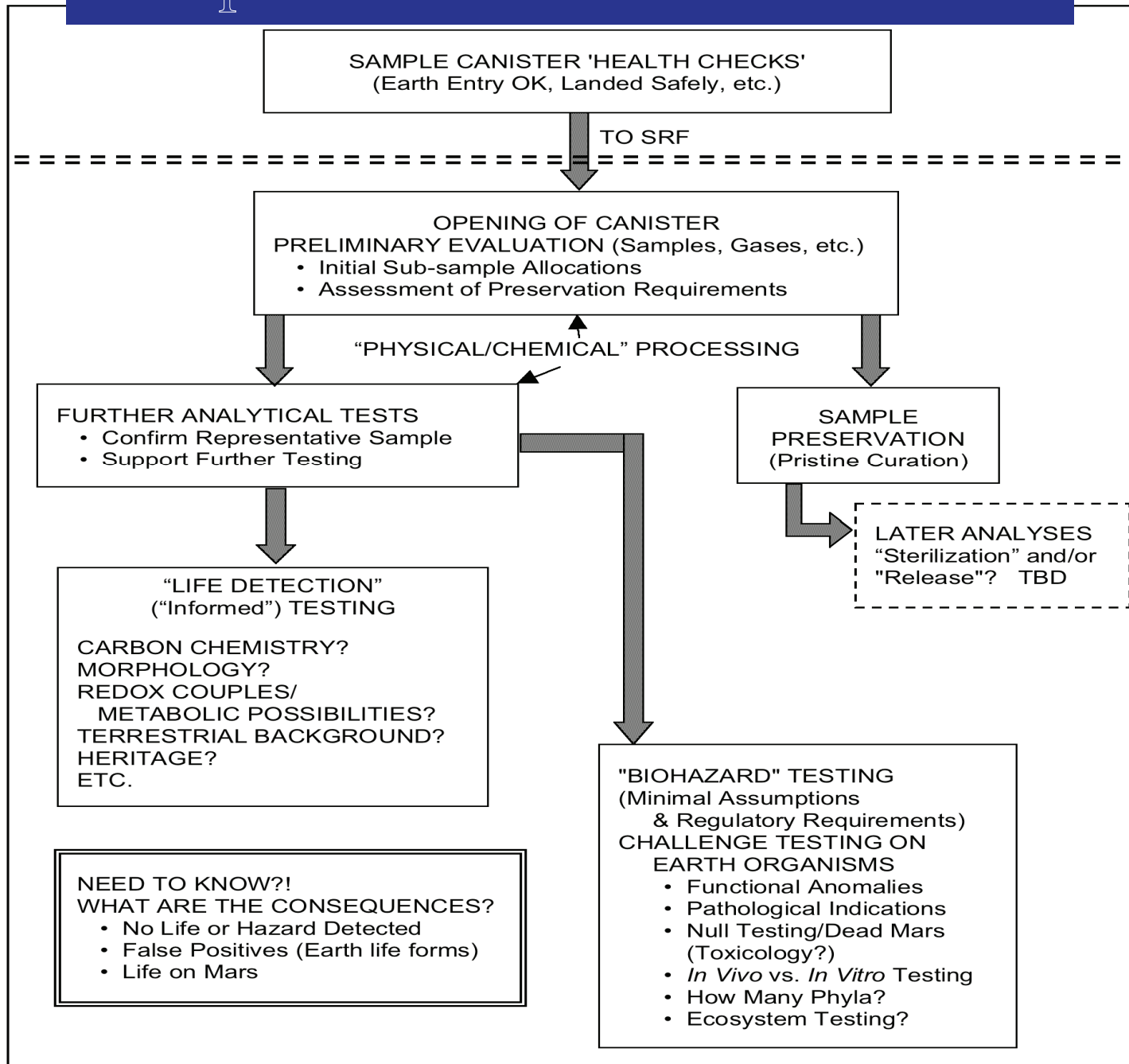
- Facility planning starts 10 years prior to sample return
- NEPA process happens before this
- Tie facility milestones to mission events



- Time Management - Influencers
 - NEPA
 - Process
 - Community Acceptance
 - Environmental Impact Statement
 - Site Selection
 - Design Approval
 - Construction & Commissioning
 - Mars Exploration Program

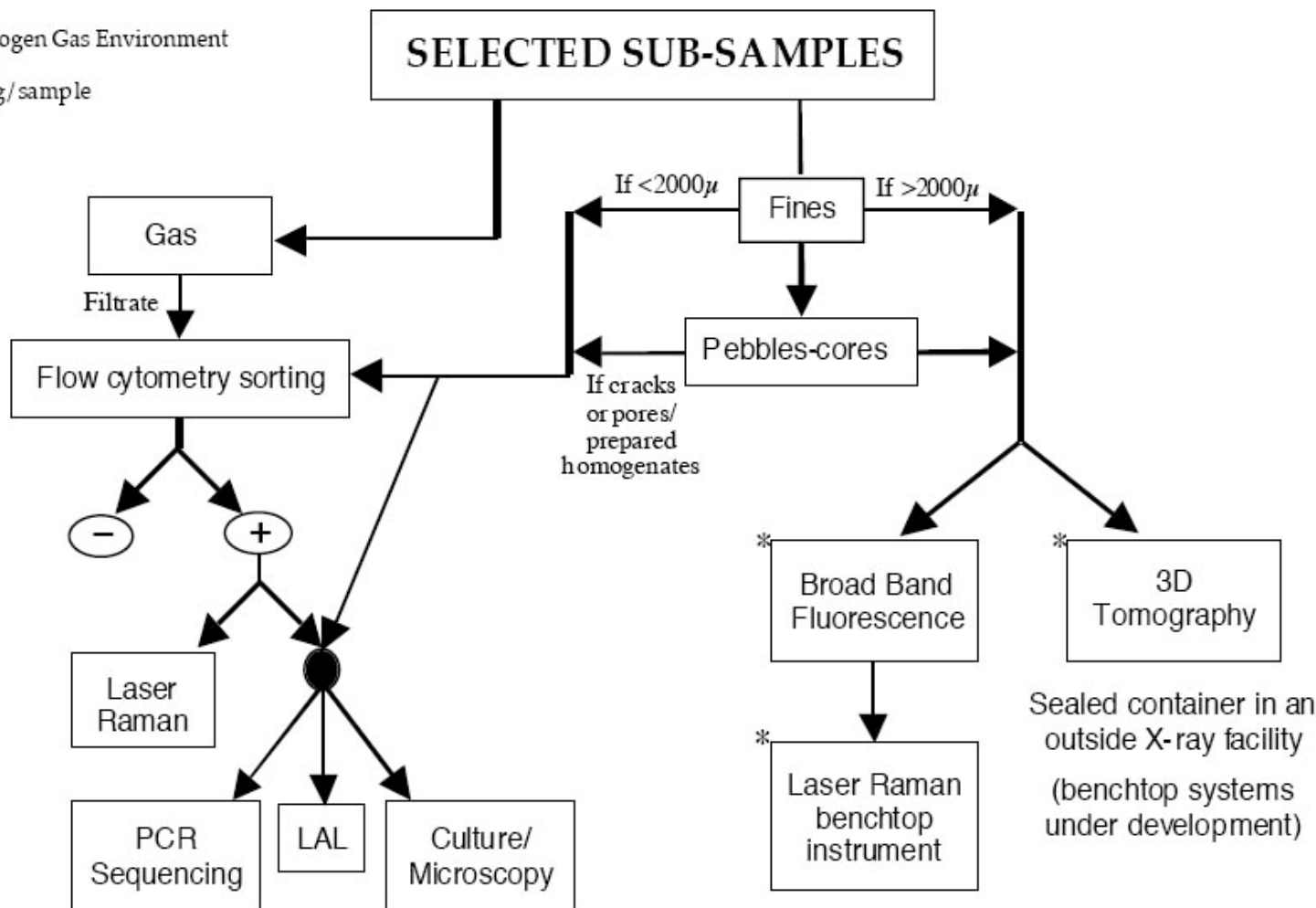
- Project Schedule Milestones
 - Early start concept design/site selection
 - Late start concept design/site selection
 - Select analytical equipment
 - Start design
 - Start construction
 - Start training and EVTs
 - Receive samples

Sample-Return Protocol Overview



Notional Life Detection Assays

Nitrogen Gas Environment
15C
1 mg/sample



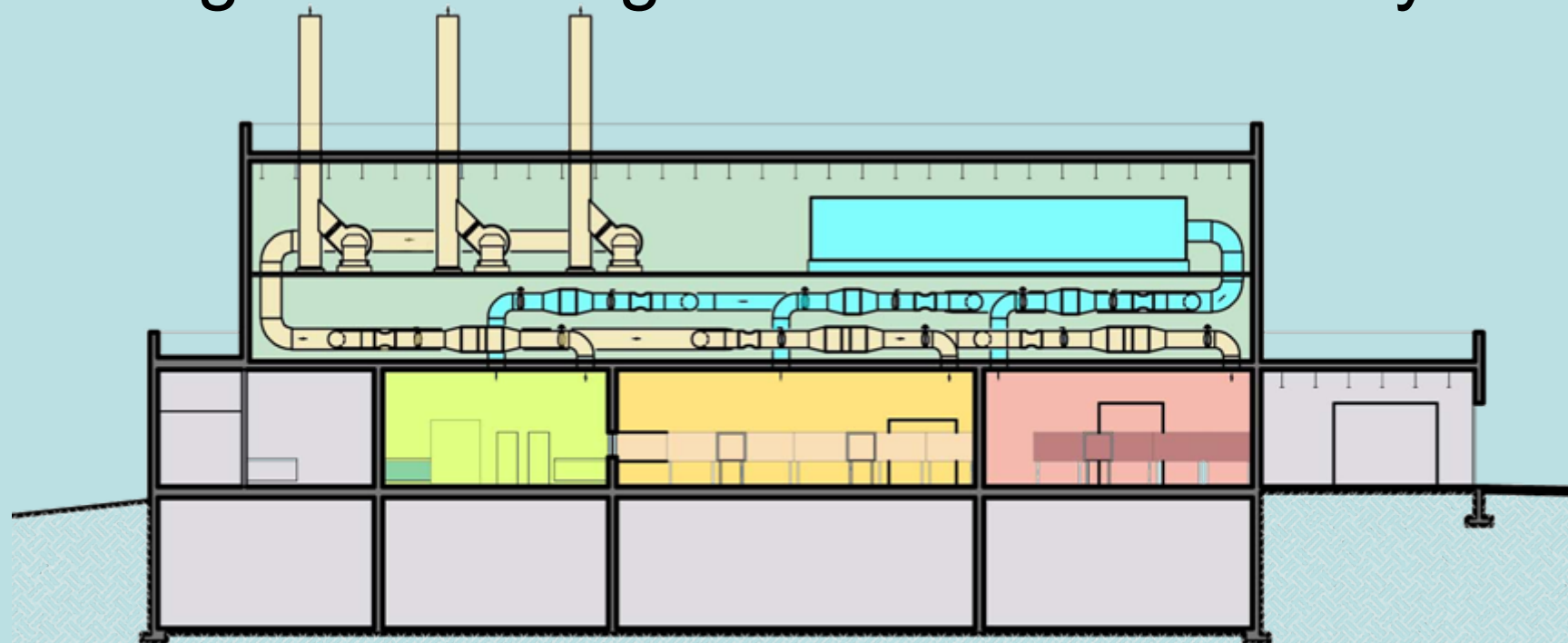
Non-destructive

NASA/CP 2002-211842

A Draft Test Protocol for Detecting Possible Biohazards in Martian Samples Returned to Earth October 2002

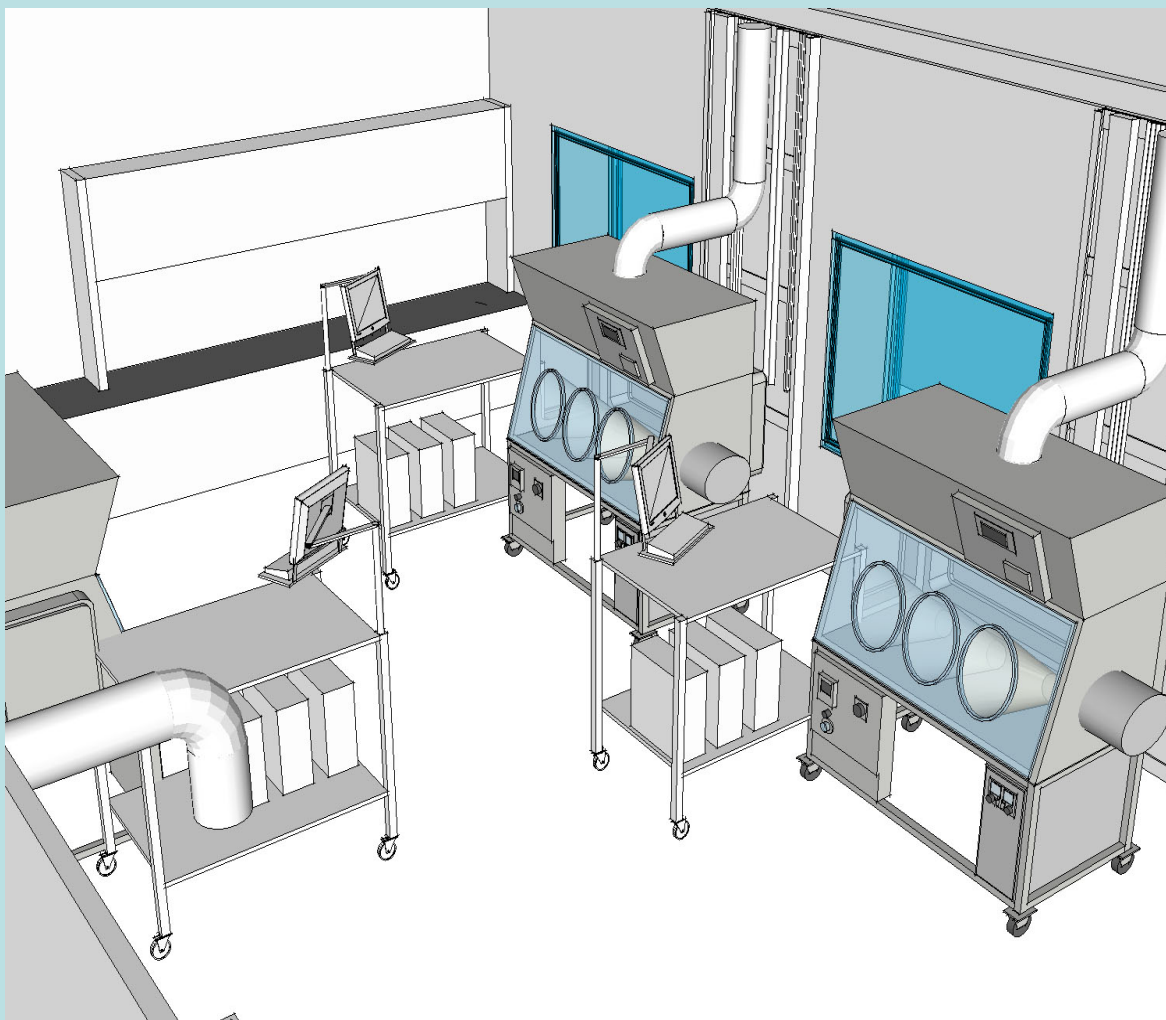
- A Sample Return Facility will require combining technologies used for constructing maximum containment laboratories (e.g. Biosafety Level 4 labs), which will be needed to ensure protection of Earth from the Mars samples, with cleanroom technologies, which will be needed to protect the Mars samples from Earth contamination.
- Such an integrated facility is not currently available.

Diagram of a High-Containment Facility



- Two floors of infrastructure per floor of containment
- Three times the area of high-containment space in support laboratories

Complex Air Flow Requirements

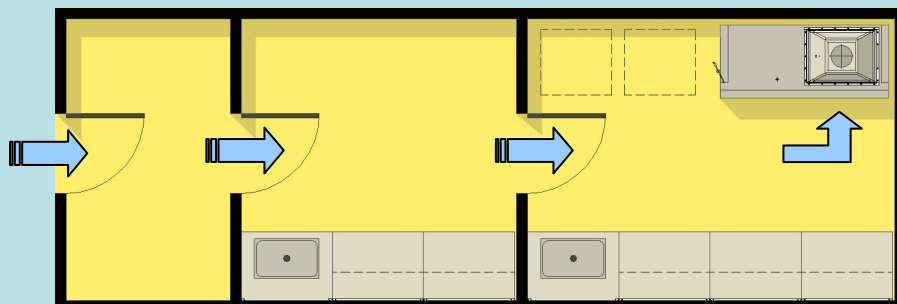


Planetary Protection Requires Negative Air Flow to Protect Against Environmental Contamination

Planetary Science and Planetary Protection Require Positive Air Flow to Protect Samples from Terrestrial Contamination

SRF Construction

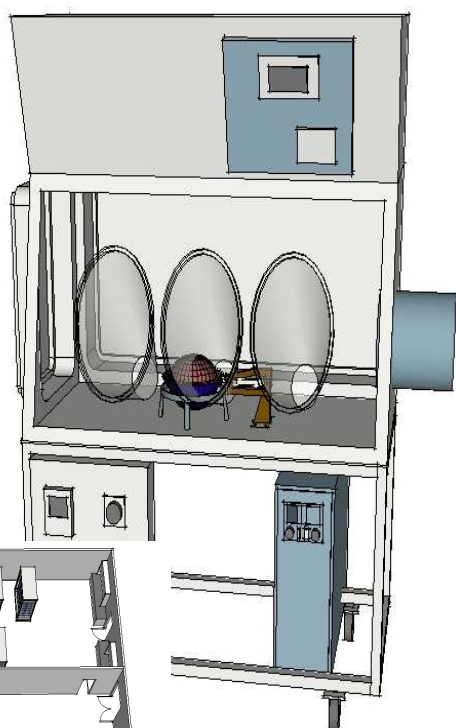
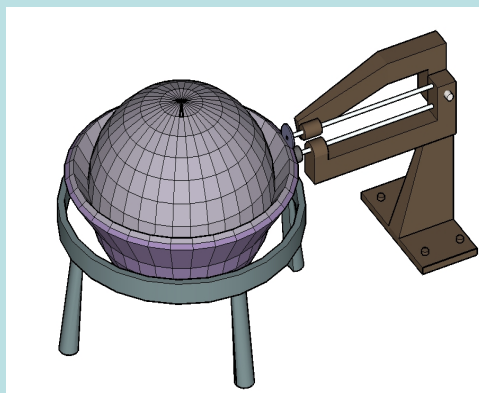
Facility uses successive series of 5-6 negative pressure levels to the outside in 25 to 50 Pa increments. This ensures the protection of the population and the environment.



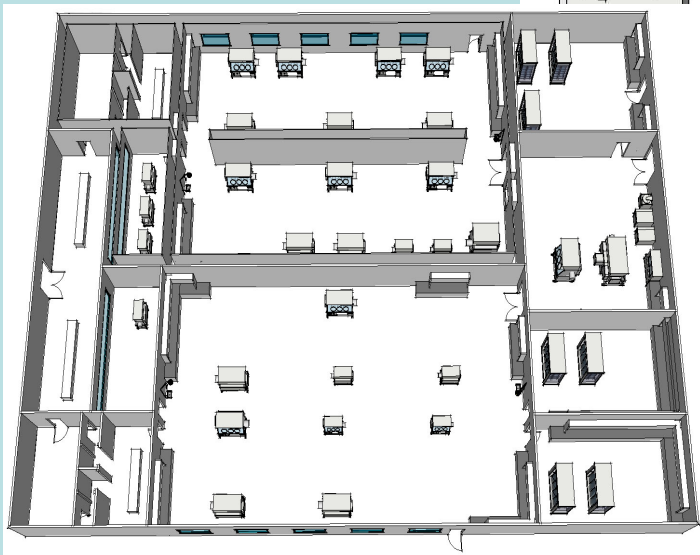
Protection of the sample from terrestrial contamination will be based on the careful selection of materials used in the facility, use of carbon filters, and particulate cleanroom classes – e.g., ISO 3 for BSC III and ISO 7/grade B for BSL-3 level around the cabinets.



Possible Sample Handling Approach



Double-walled chamber maintains negative pressure between walls



Public Concerns about High Containment Laboratories

Laboratory biosafety lapses have led to public questions regarding safety and location of high containment facilities.

- Texas A&M work suspended by CDC
- Boston BL4 laboratory operation delayed by environmental safety challenges and court orders

Congress has begun a series of hearings on biosafety of high containment facilities

- **House Energy and Commerce Committee Subcommittee on Oversight and Investigations “increasing concerns...raised about the safety, as well as operations” of high-containment laboratories**
- **Hearing October 4, 2007: “Germs, Viruses, and Secrets: The Silent Proliferation of Bio-Laboratories in the United States”**

PPS Recommendation, meeting of 7 Aug 07

- The Planetary Protection Subcommittee recommends that NASA actively engage in the advanced planning processes necessary to accommodate the appropriate containment of samples returned from Mars.
- To this end, the Planetary Protection Subcommittee recommends that NASA should update existing documents, and obtain specific planning advice to prepare for Mars sample return missions.

PPS Recommendation, meeting of 7 Aug 07

- Without appropriate planning, and in the absence of a well-established and suitable sample receiving and containment facility, samples could not be returned from Mars without potentially endangering the Earth, and violating our international agreements.
- Critical exploration and science activities that depend on Mars sample return could be delayed or precluded.

Consequences of no action on the Recommendation

- Without appropriate planning, and in the absence of a well-established and suitable sample receiving and containment facility, samples could not be returned from Mars without potentially endangering the Earth, and violating our international agreements.
- Critical exploration and science activities that depend on Mars sample return could be delayed or precluded.

Conclusion

- Compliance with Planetary Protection Requirements is Mandatory
- It will take at least a decade to bring an adequate sample receiving facility on line
- NASA must act now to plan for the construction of a receiving facility in order to meet planetary protection requirements for samples to be returned from Mars!

Category IVb Requirements for Mars

Category IVb missions comprise lander systems carrying instruments designed to investigate extant Martian life. For such missions, the following requirements apply:

Either the entire landed system must be sterilized to the microbial burden levels defined in the specification sheet "Maximum Surface Microbial Spore Burden for Category IVb and IVc Missions to Mars," or to levels driven by the nature and sensitivity of the particular life-detection experiments, whichever are more stringent.

OR

The subsystems that are involved in the acquisition, delivery, and analysis of samples used for life detection must be sterilized to burden levels defined in the specification sheet "Maximum Surface Microbial Spore Burden for Category IVb and IVc Missions to Mars" and a method of preventing recontamination of the sterilized subsystems and the contamination of the material to be analyzed is in place.