Mars Sample Return Planning: Sample Containment and The Draft Test Protocol

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Planetary Protection Subcommittee (PPS) Meeting
NASA HQ August 4, 2010

MSR, Containment &The Draft Protocol

Decision Making about Planetary Protection

Context:

- Containment
- Accumulating Information & Iterative Process

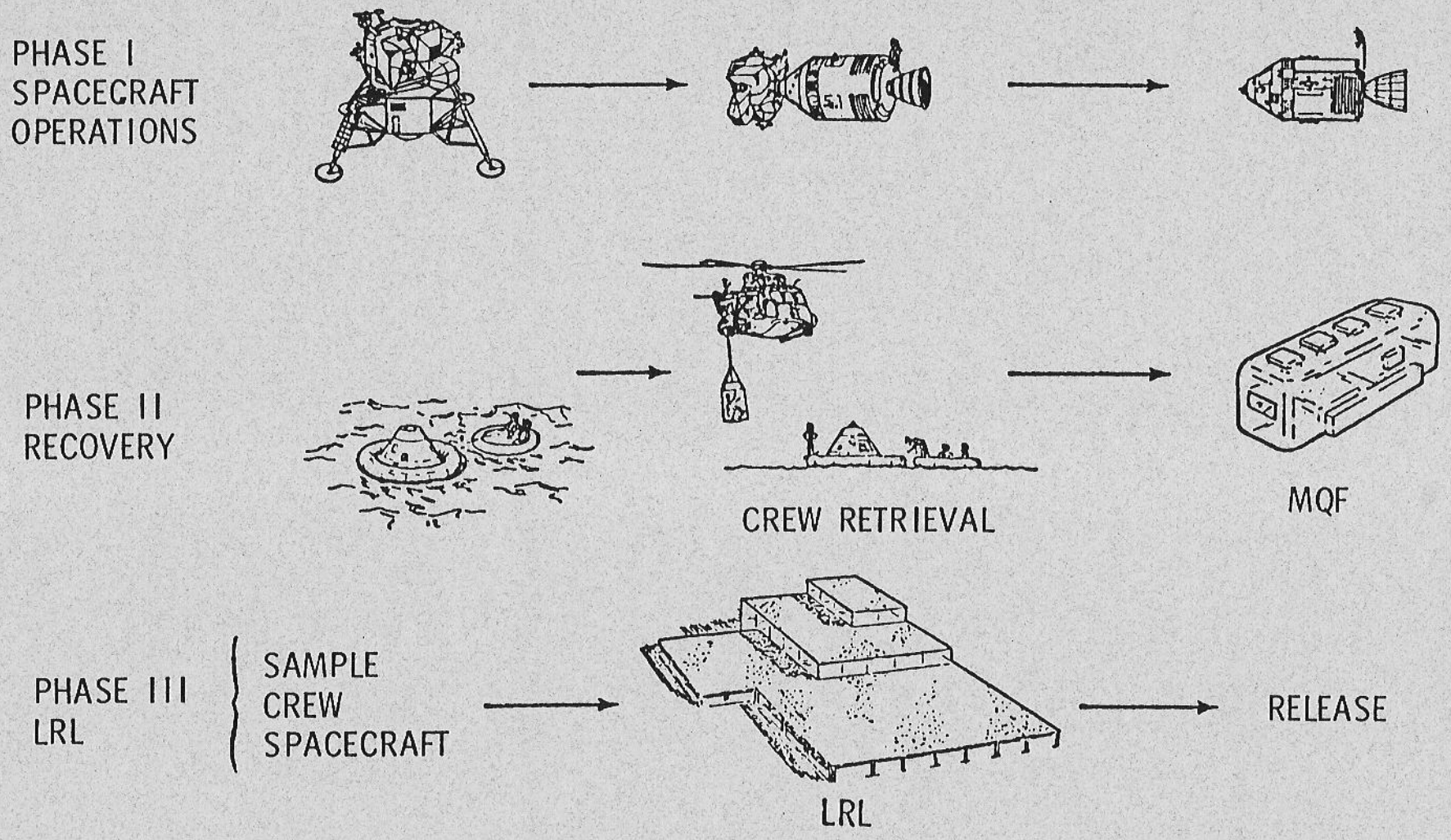
Priorities -- Identifying Needs

- Science– Biological vs. Planetary
- Legal / Policy
- Facility/Technical

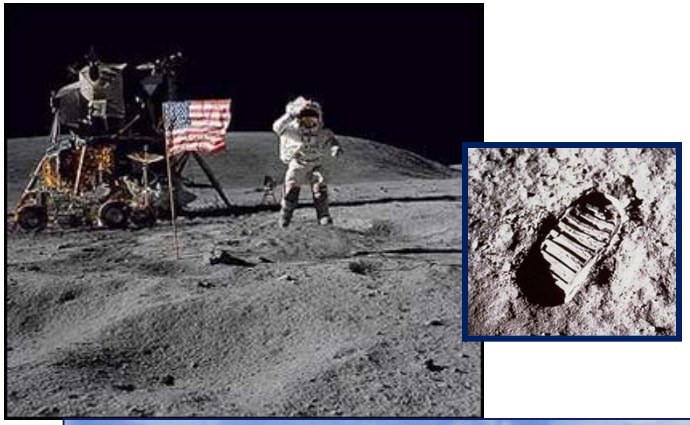
Process in Retrospect - Strategies

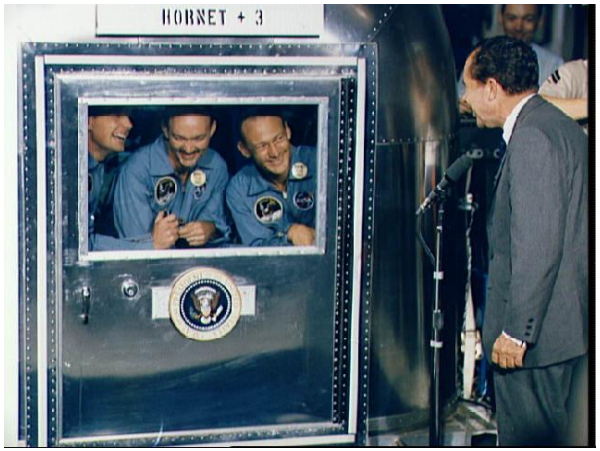
Lessons Learned… and Issues TBD

Sample Return Mission: Many Technologies, Activities, Locations

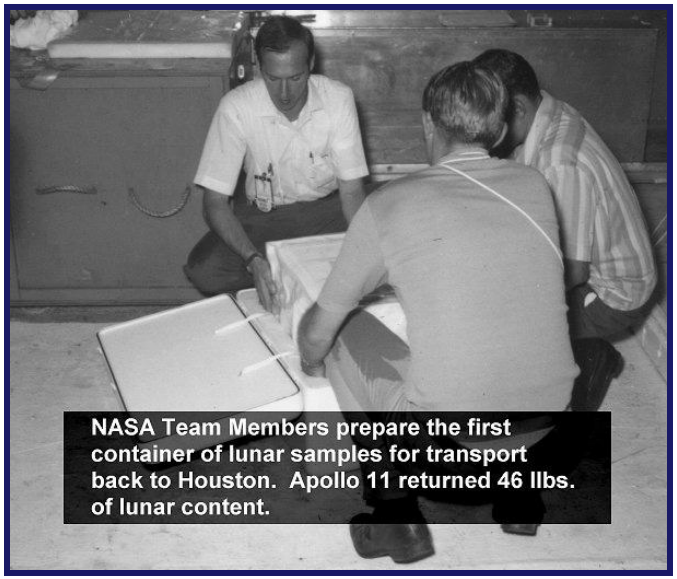


APOLLO BACK CONTAMINATION PROGRAM

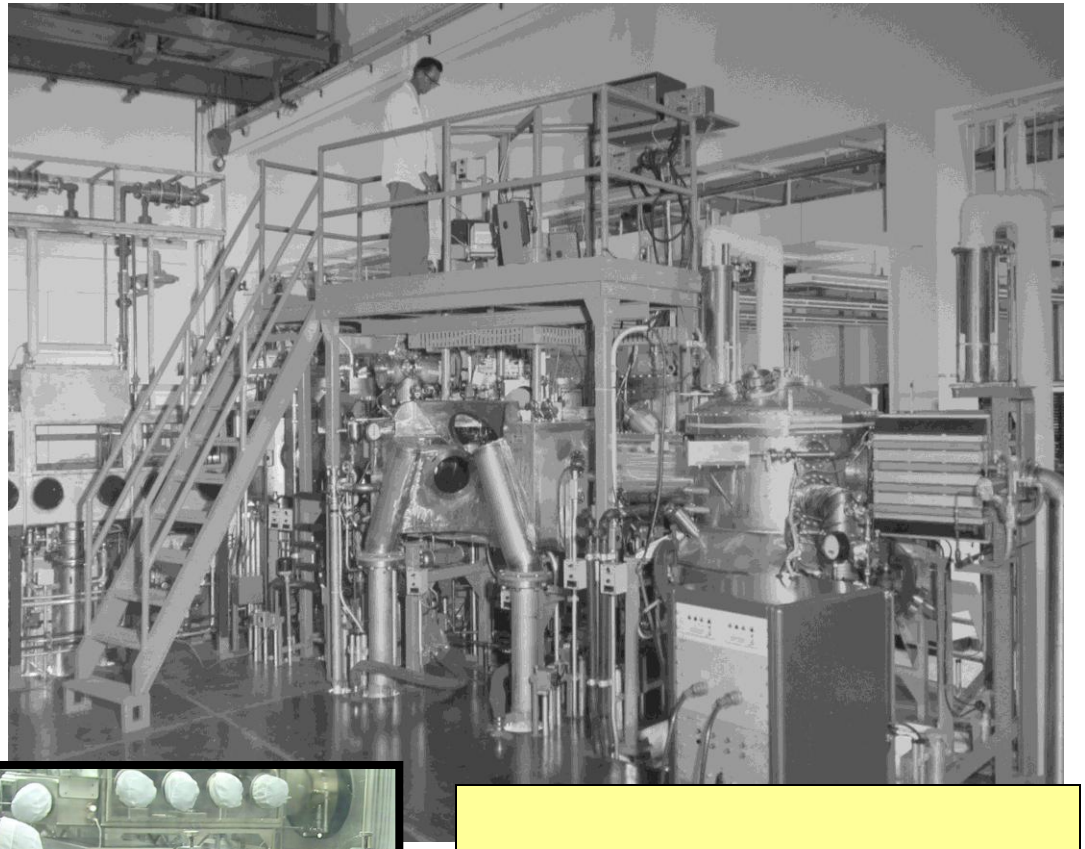




LUNAR ASTRONAUTS returning to earth on Apollo
like vehicle currently being manufactured by Ai
of Westinghouse Air Brake Company. The "Mobile
program to prevent possible contamination of th



NASA Team Members prepare the first container of lunar samples for transport back to Houston. Apollo 11 returned 46 llbs. of lunar content.



Rigorous Test Protocol…
No ET Life or Biohazards On the Moon…

Astronauts and Rocks Released From Quarantine

Fast Forward to ‘90’s

Meteorite Allan Hills (ALH) 84001 (NASA)

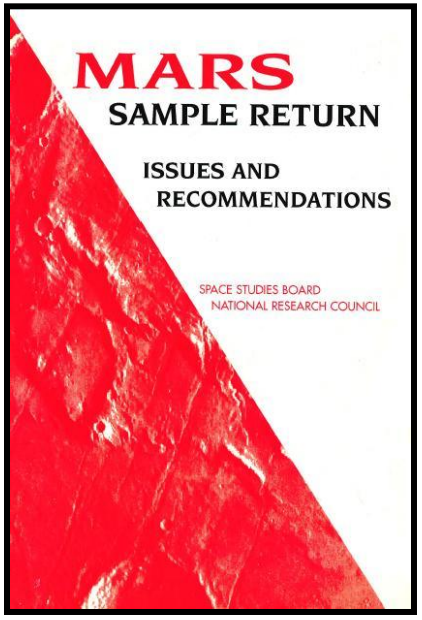

The elongated structure in the center maybe a microfossil

- **Martian Meteorite** (Aug. 1996)
- **Pathfinder and Sojourner** (July ‘97)

Even as ALH debate continued…

- NASA began Planning MSR missions–
  - Mars opportunities every 26 months
  - 2003, ‘05, Samples Returned ’07
- Recognized changes since Apollo
  - Science, technology, legal/policy, public
- Misc. studies underway.. MELTSWG (Quarantine, Curation, etc.)
- NASA Asked NRC to study MSR issues (‘96-97)

- NASA Charge to Committee:
  - Likelihood of Return ET Life in Samples
  - Risk of Pathogenicity or Large Scale Impacts
  - How Reduce risks?



1997

- NRC Recommended: Conservative Approach
- Containment
  - Samples contained & treated as potentially hazardous
  - No uncontained martian materials returned to Earth (unless sterilized)
  - Break Chain of Contact with Mars; Maintain Containment Integrity
  - On Earth, No distribution of unsterilized materials unless
    - Rigorous analyses demonstrate no ET life or biological hazard
    - Materials sterilized first
- Sample Evaluation- Rigorous analyses… Protocol TBD
- Program Oversight
  - Establish Interagency Panel to coordinate & advise on implementation
  - Administrative structure within NASA to verify & certify PP adherence
- Keep Public Informed

Priorities/ Issues of Importance- *Pre*-Protocol Workshops

No Existing Facility meets containment & science needs
Tension over Biohazard and Planetary Science Needs (cleanliness)

- Containment- Build on Apollo but update and revise
  - Focus on Sample Canister *and* Receiving Laboratory (BSL-4)
  - Mission Architecture– PP concerns built into many part of mission
  - Identified R&D needs (filtration; canister verification; false positives; cleanliness, sterilization, etc).
- Life Detection –Preliminary Protocol built on
  - Organic chemical analyses/detection (functional groups assoc. with energy transfer)
  - Light and/or electron microscopy (SEM, TEM)– for screening
  - Culturing of secondary importance
  - NASA needs to focus on new life detection technologies/methods
- Biohazard Preliminary Testing Protocol
  - Emphasized Chemical Toxicity & Pathogenicity
  - In vitro methods rather than whole organism tests
  - Microcosm tests for ecosystem effects (TBD)
  - Attempt to outline Criteria for Release (no consensus)
- Oversight/ Certification/ Verification
- Legal Requirements /Compliance
- Public Information

Mars Sample Handling/ Protocol Workshops

(Planned 1999 Implemented 2000-02)

Protocol Process

1. Workshop 1: March 2000 Bethesda MD (Rummel & Race, 2000)
2. Workshop 2: Oct. 2000, Bethesda MD (Race et al. 2001a)
3. Workshop 2a: Nov. 2000, Rosslyn VA (Bruch et al, 2001)
4. Workshop 3: March 2001, San Diego CA (Race et al. 2001b)
5. Workshop 4*, June 2001, Arlington VA (Race et al., 2001)

* Advance Copy (May 2001) of SSB/COMPLEX Rept.: Quarantine & Certification of Martian Samples

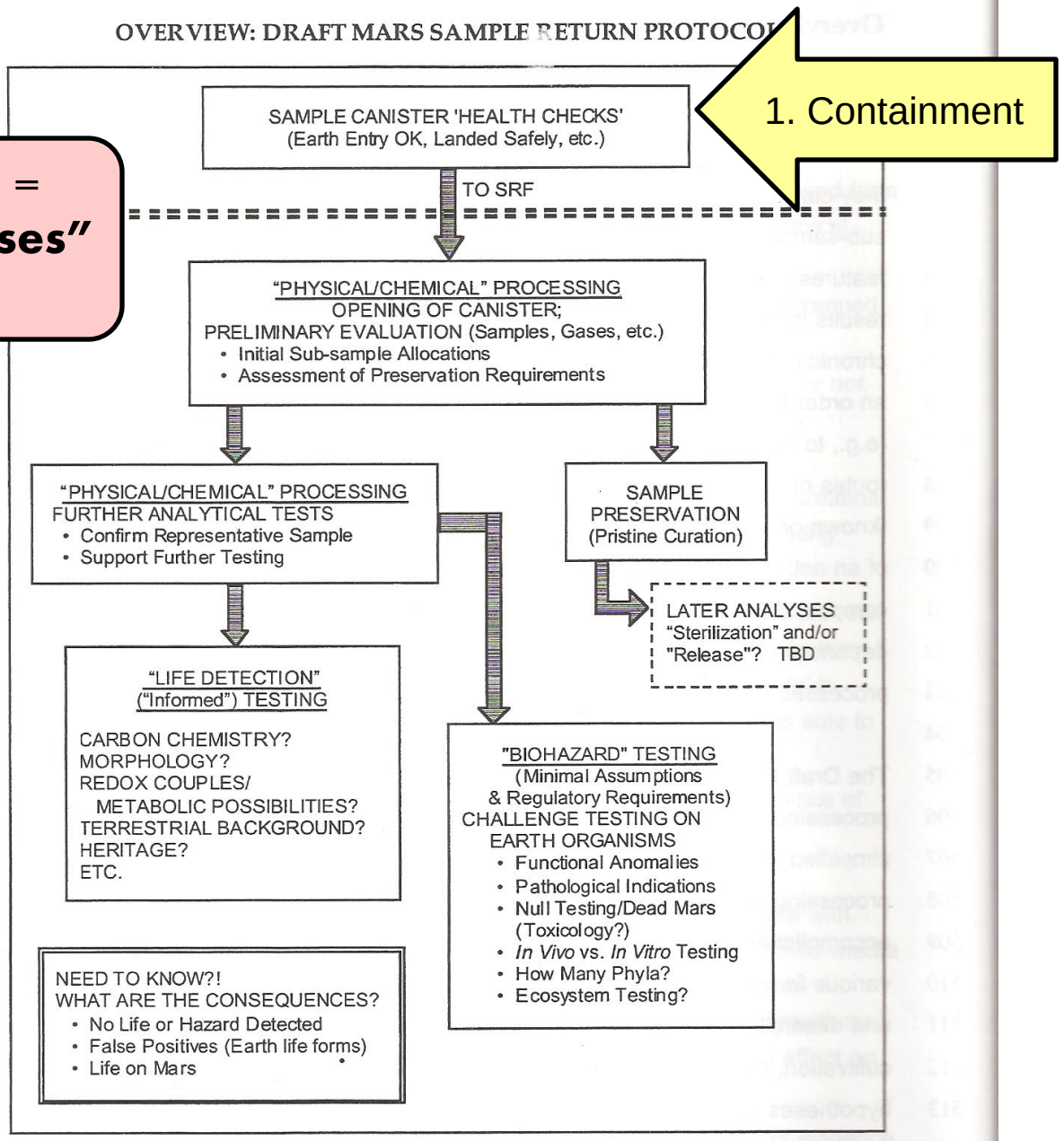
THEN

- Consensus Working Draft of Protocol, June 2001
- Oversight and Review Committee (Oct-Nov 2001) (NYC)

(NOTE: Post 9/11 and Anthrax Attacks)

- **Draft Test Protocol for Detecting Possible Biohazards in Martian Samples Returned to Earth (October 2002)**

Entire Protocol = "Rigorous Analyses" Plus...



518
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520 segments: Physical/Chemical processing, Life Detection, and Biohazard testing.

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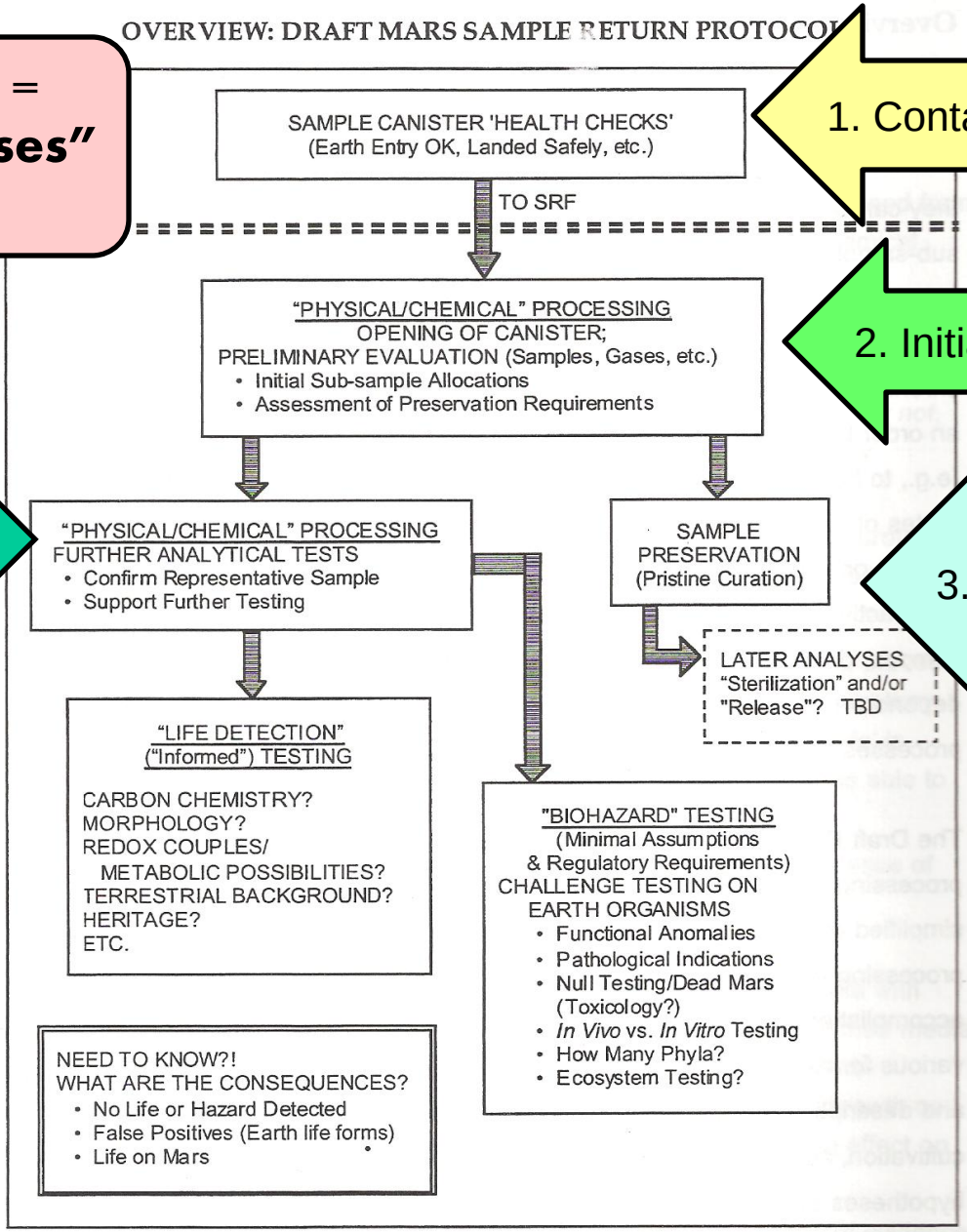

1. Containment

2. Initial Processing

3. More P/C tests; sample selectione

3. Pristine Curation

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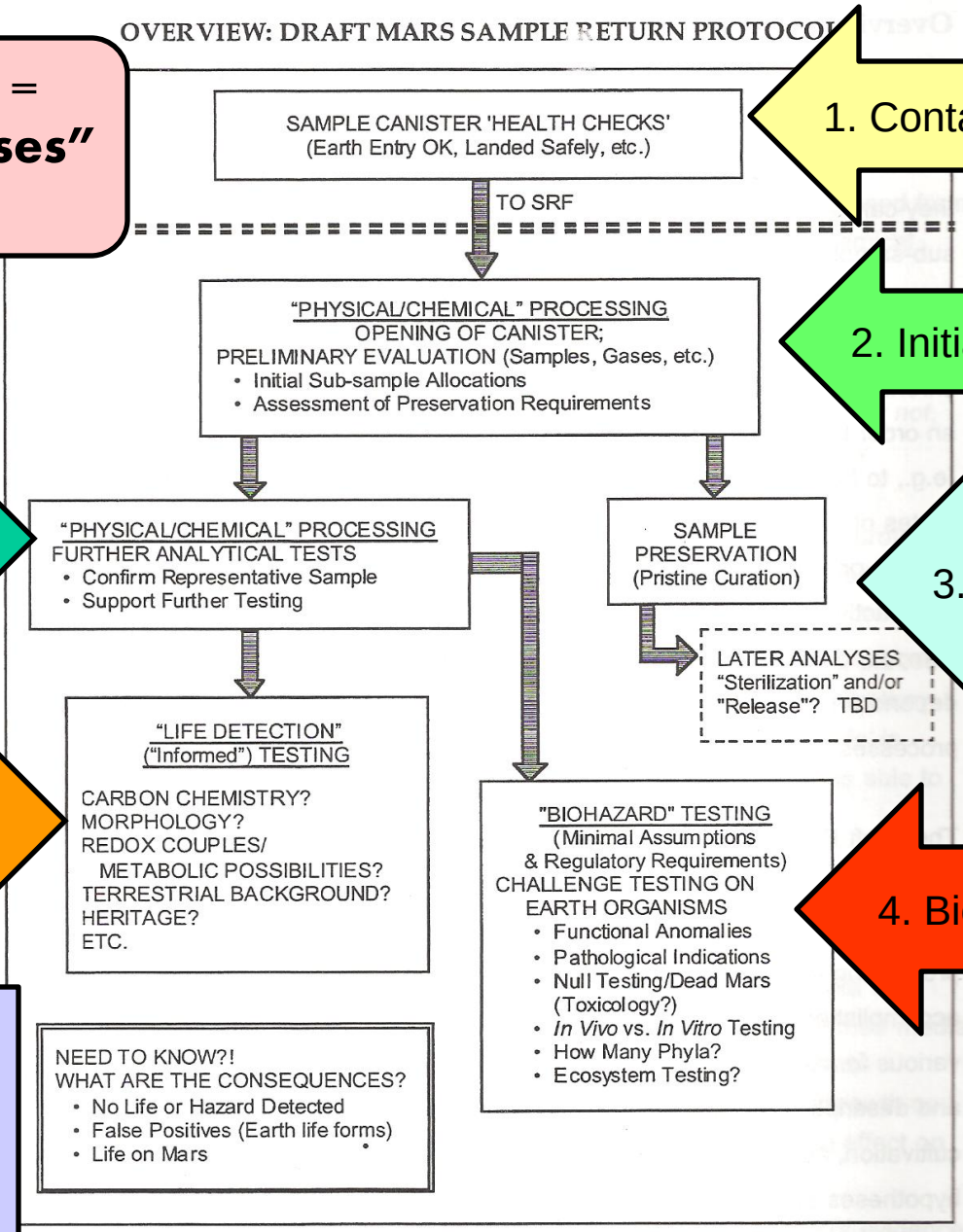

1. Containment

2. Initial Processing

3. More P/C tests; sample selectione

3. Pristine Curation

4. Life Detection

4. Biohazard Testing

Environment & Health Monitoring and Safety

Database & Info Handling

Personnel Management, Training, Oversight Committees

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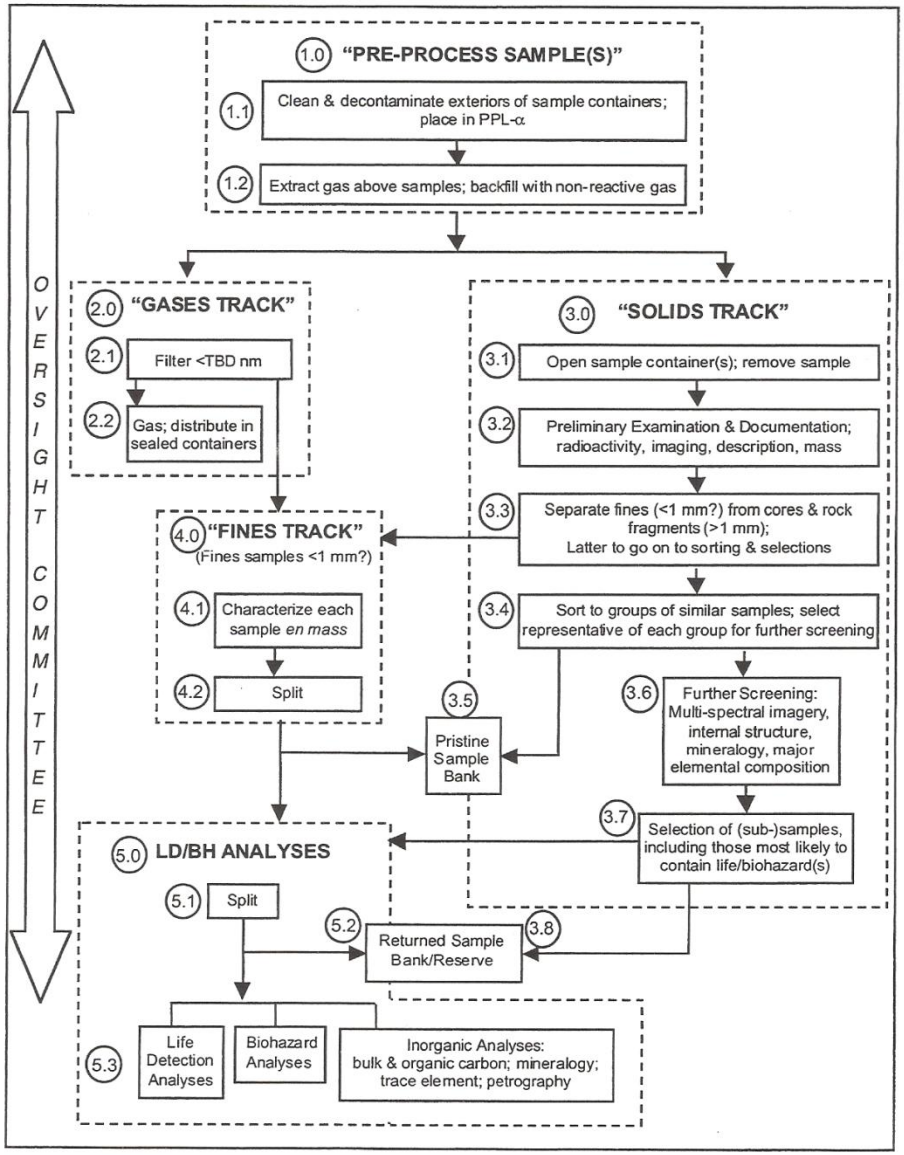


Figure 3. The Physical/Chemical processing will occur in four sequential stages leading into the Life Detection and Biohazard testing. The numeric annotations refer to numbered sections of text below, which elaborate on the proposed P/C steps.

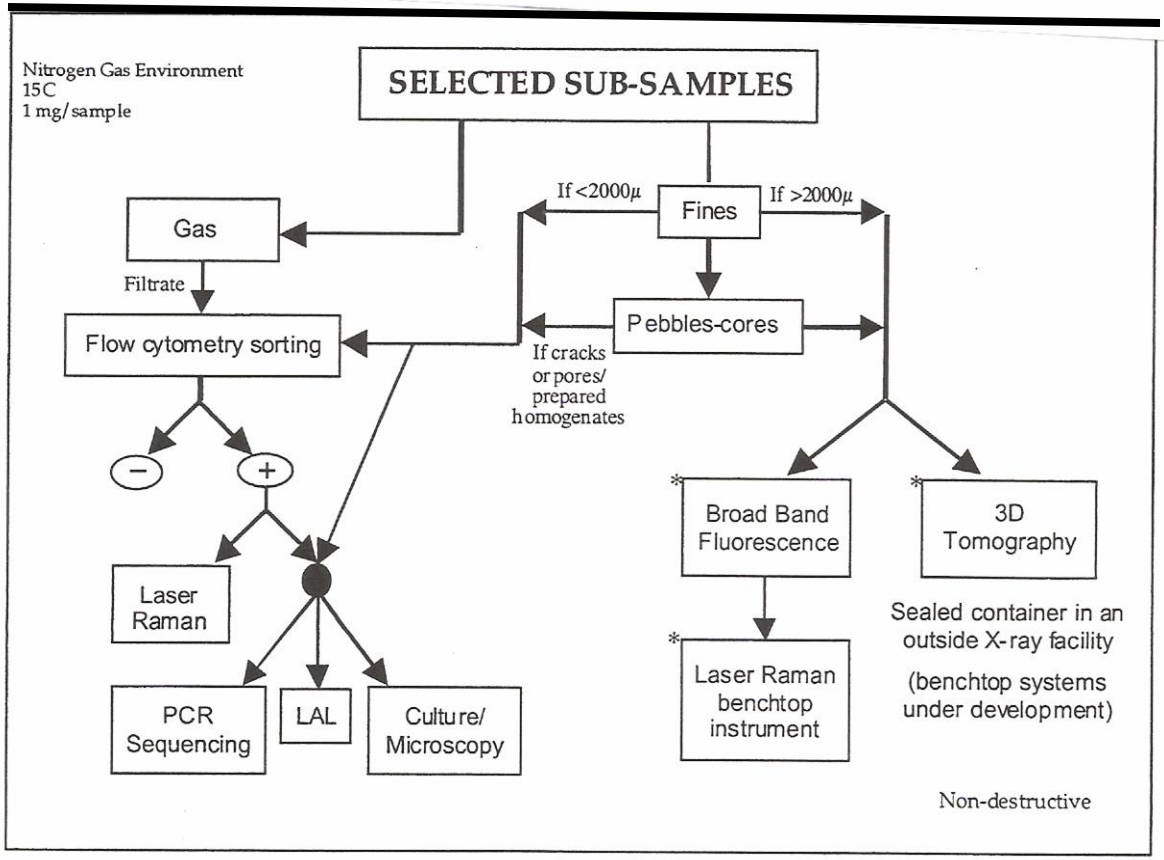
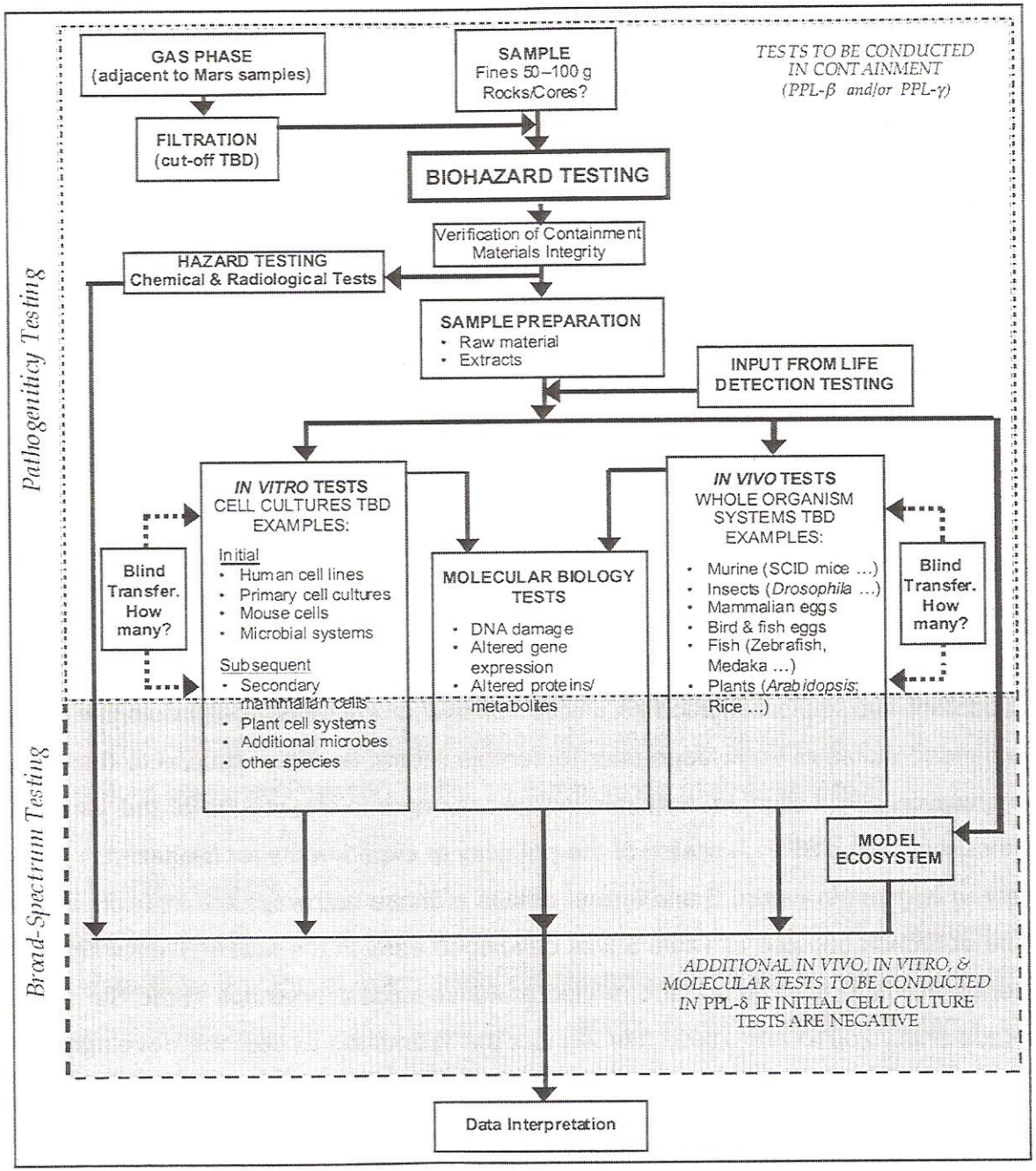


Figure 4. Life Detection Process Flowchart.


GAS PHASE
(adjacent to Mars samples)
SAMPLE
Fines 50–100 g
Rocks/Cores?
TESTS TO BE CONDUCTED
IN CONTAINMENT
(PPL-β and/or PPL-γ)
FILTRATION
(cut-off TBD)
BIOHAZARD TESTING
Verification of Containment
Materials Integrity
HAZARD TESTING
Chemical & Radiological Tests
SAMPLE PREPARATION
• Raw material
• Extracts
INPUT FROM LIFE
DETECTION TESTING
Pathogenicity Testing
IN VITRO TESTS
CELL CULTURES TBD
EXAMPLES:
Initial
• Human cell lines
• Primary cell cultures
• Mouse cells
• Microbial systems
Subsequent
• Secondary mammalian cells
• Plant cell systems
• Additional microbes
• other species
MOLECULAR BIOLOGY
TESTS
• DNA damage
• Altered gene expression
• Altered proteins/ metabolites
IN VIVO TESTS
WHOLE ORGANISM
SYSTEMS TBD
EXAMPLES:
• Murine (SCID mice ...)
• Insects (Drosophila ...)
• Mammalian eggs
• Bird & fish eggs
• Fish (Zebrafish, Medaka ...)
• Plants (Arabidopsis; Rice ...)
Blind
Transfer.
How
many?
Blind
Transfer.
How
many?
MODEL
ECOSYSTEM
Broad-Spectrum Testing
ADDITIONAL IN VIVO, IN VITRO, &
MOLECULAR TESTS TO BE CONDUCTED
IN PPL-δ IF INITIAL CELL CULTURE
TESTS ARE NEGATIVE
Data Interpretation

PPL-type	Biocontainment	Cleanliness	'Ambient' Conditions	Used For:
PPL-α	Maximum (BSL-4)	Maximum	Mars-like (pristine); *Although at 1 atm w/inert gas environment.*	Incoming container and materials; some preliminary tests; sample bank/storage; some Life Detection
PPL-β	Maximum (BSL-4)	Maximum	Earth-like	Life Detection; some Physical/Chemical; TBD
PPL-γ	Maximum (BSL-4)	Moderate	Earth-like	Some Biohazard testing, some Physical/Chemical processing, and animal testing
PPL-δ	Strict BSL-3-Ag	Ambient	Earth-like	Some Biohazard testing; 'post-release' tests TBD

Table 1. Anticipated laboratory conditions and PPL categories. Note: Levels of cleanliness associated with each PPL are TBD and should be defined explicitly well in advance of sample return.

Containment
CDC-NIH Guidelines
PLUS…

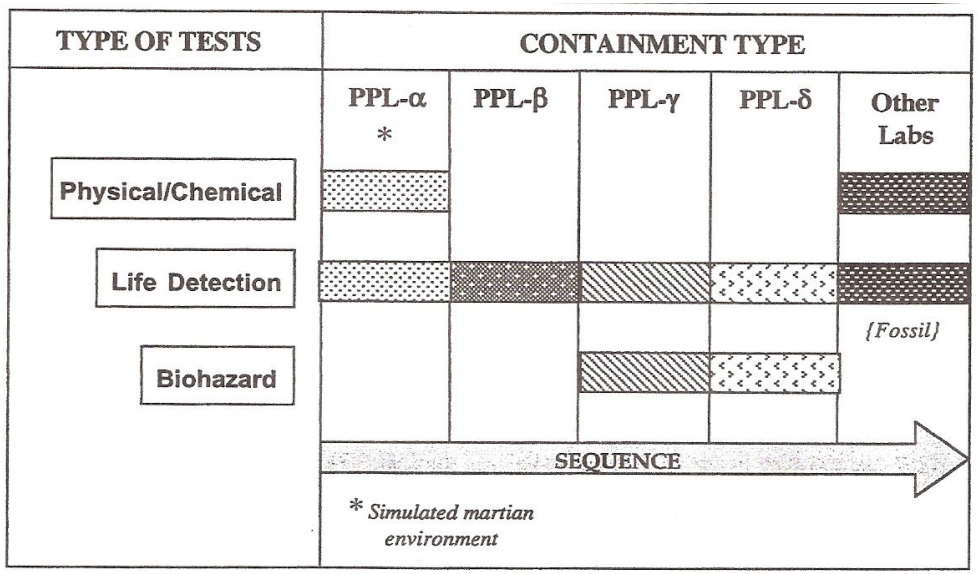


Figure 6. Sequential containment requirements by test category.

Additional Considerations Related to Containment and Protocol

Facility, Technological & Other Concerns

- ? If ET life discovered: Review adequacy of facility, tests, equipment and emergency plans etc.
- International Complications? (where will sample go?)
- Need organized Communication Plan in advance
- Contradictory/Inconsistent Results– Multidisciplinary Input
- Ensure application of Release Criteria (international review)
- Anticipated Breach of Containment/Emergency Plans
- Documentation of Operations, Biosafety etc.

Maintain and Update Protocol

- International review with partners (national academies of science)
- Ethical and Public Reviews of Sample Return
- Future Modifications to Protocol (in advance and real time)

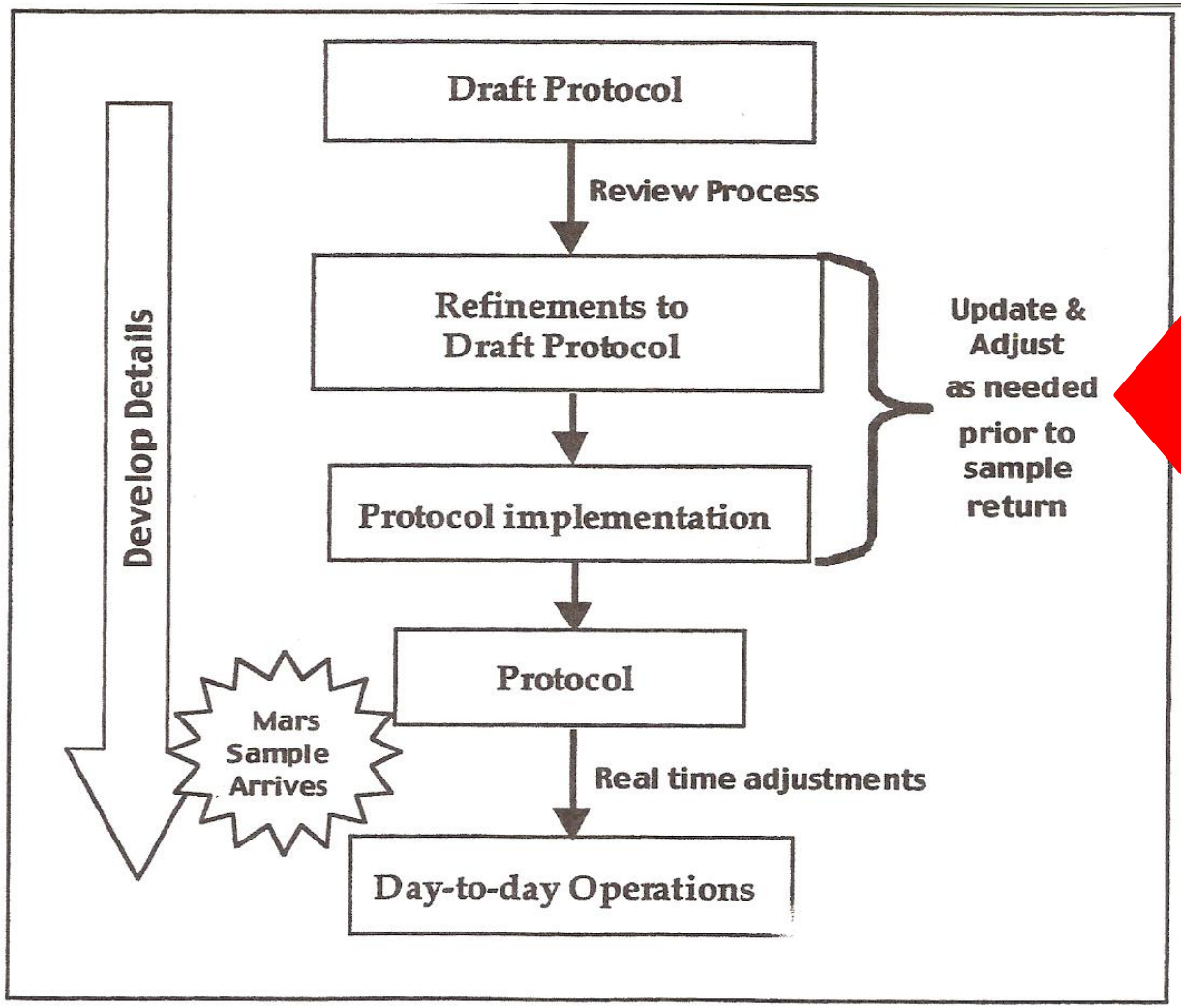


Figure 11. Protocol update and implementation process.

Where We Stand Now

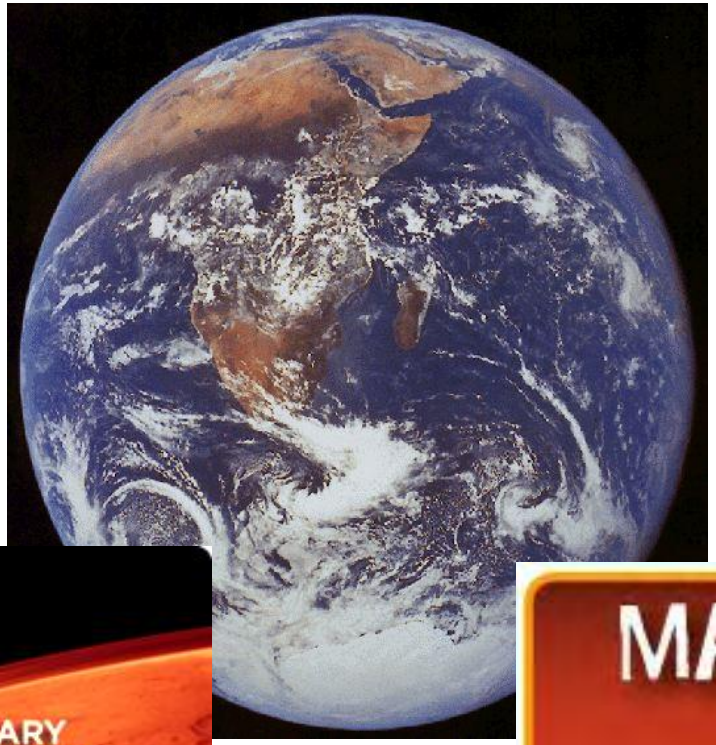
2009 NRC Study: Reassessment of MSR

- Concur with 1997 Study plus:
  - Verify Seal- Emphasis on containment rather than Monitoring en route
  - Need Examine Samples at Microscale (address sample heterogeneity)
  - Small Amounts of Materials (Representative; Non-Destructive?)
  - Transport Containers (multiple labs?)
  - Criteria for Release TBD
  - Longer Time to Commission Labs (10 years +)
- Other Concerns
  - EIS complications? (Based on BSL-4 lab concerns)
  - Question about Animal Studies- (Needed? Advances in Molec. Biol.)
  - False Positives of concern to both PP and Science
  - Public Opposition? ($$; Risks; ex. ICAMSR)
  - Wild Card: ET Discovery; Ethics and PP

NASA-ESA Joint MSR missions: 2016, 2018, 2020+

Report/Event	96	97	98	99	2000	01	02	03	04	05	06	07	08	09	10
ALH 96	x														
Pathfinder 97		x													
MELTSWG 95-97		X													
NASA AB Roadmap			X					X					X		
NRC MSR Study	X	X													
NRC Small Bodies			X												
MSHARP			X	X											
NRC size limits			X												
Planning DP				X											
NRC Q & Certif.					X	X	X								
Workshop 1					x										
Workshop 2					x										
Workshop 2a					x										
Workshop 3						X									
Workshop 4						X									
Blue Ribbon Review						X									
DP Published							X								
BSL-3,-4 labs							X	X	X	X	X	X	X		
Planned MSR								X		X		X			
Mars MERs, A/E study of SRF, IMARS, Phoenix, MEPAG SAGs, NRC Decadal studies on Mars etc.										X	X	X	X	X	X
NRC Reassess MSR													X	X	

QUESTIONS?




NASA
PLANETARY PROTECTION: ALL OF THE PLANETS, ALL OF THE TIME


MARS
ENCOUNTER