MSR: Breaking the Chain of Contact

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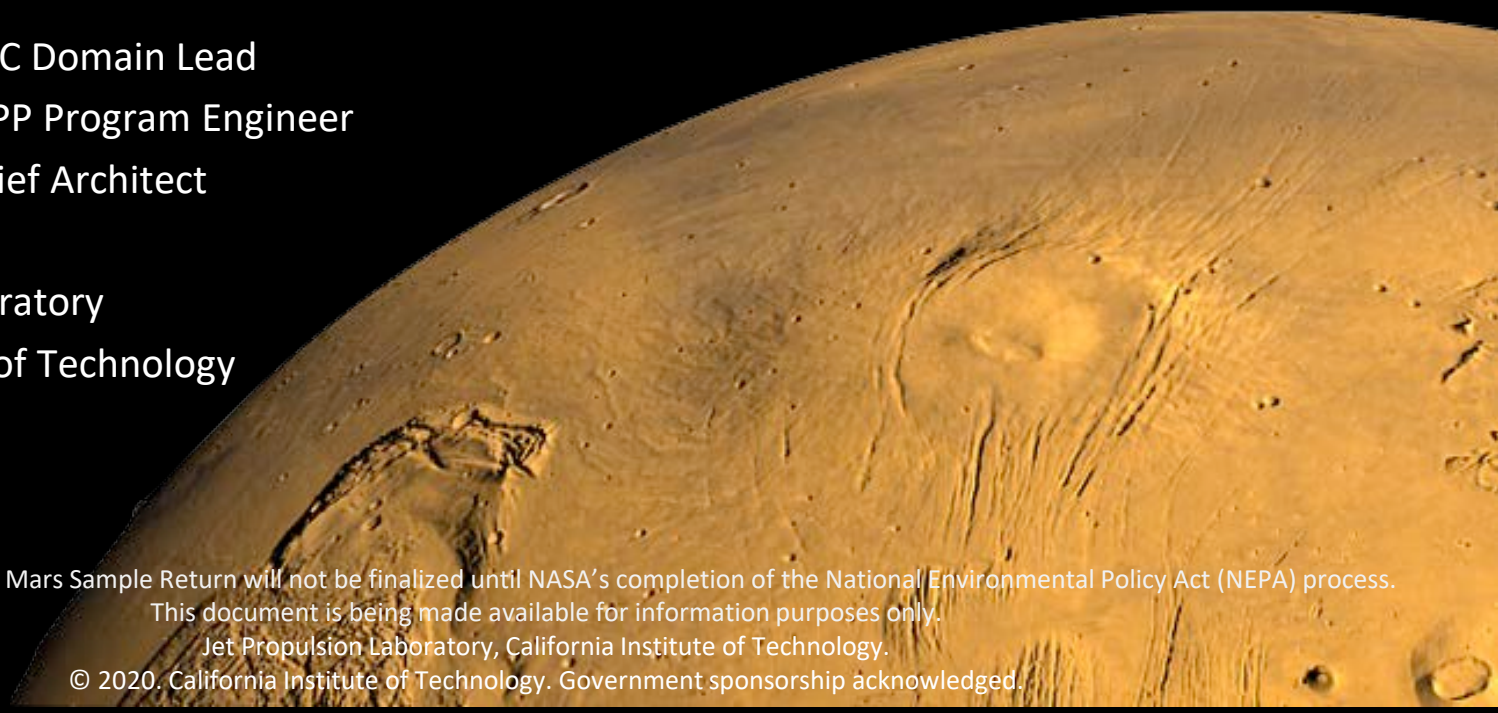


Introduction

- The Mars Sample Return (MSR) Program would be the first endeavor since Apollo to deliver material to Earth from a body of potential biological interest

- NASA's "Category V restricted return" classification frames the Backward Planetary Protection requirements that MSR would be required to satisfy
  - MSR is working to establish its technical response (and eventually specific requirements) to the applicable NASA Procedural Requirements (NID 8020.109A):
    - "Unless the sample to be returned is subjected to an accepted, approved, sterilization process, the sample container must be sealed after sample acquisition, and a redundant, fail-safe containment with a method for verification of its operation before Earth-return shall be required."
    - "The mission and the spacecraft design shall provide a method to "break the chain of contact" (BTC) with Mars. No uncontained hardware that contacted Mars, directly or indirectly, may be returned to Earth unless sterilized.."
  - This is consistent with COSPAR Backward Planetary Protection (BPP) guidance

- MSR team recognizes the seriousness of restricted sample return
  - Early work building a toolset to "break the chain (BTC) of contact" with Mars
  - Supported by robust modeling, testing, and system verification

General BPP Strategic Approach

- NASA is developing an overall strategic approach for BPP
  - NASA Planetary Protection Officer (PPO) initiating an effort with an international group of scientists to assess the risk of Mars material to Earth's biosphere
  - MSR Campaign is actively designing systems, verification approaches, and operational strategies consistent with Break the Chain (BTC) and Containment Assurance (CA) objectives

- The MSR Campaign would lead this strategic approach through the Campaign System Engineering Management Office
  - The strategic approach will lead to a detailed implementation plan
  - Will address roles between NASA and ESA

- National Environmental Policy Act (NEPA) process will be initiated with inter-agency procedures and all appropriate stakeholders

BTC/CA Overview

- Break the Chain (BTC) and Containment Assurance (CA) are two of the many elements that contribute to BPP for MSR, and they are managed through engineering design, margins, analysis, and test

- Break the Chain (BTC) is an **active, surface-to-surface (Mars-to-Earth)** process to satisfy Backward Planetary Protection (BPP) goals by prohibiting uncontrolled transmission and release of **Mars material of concern** into Earth's biosphere

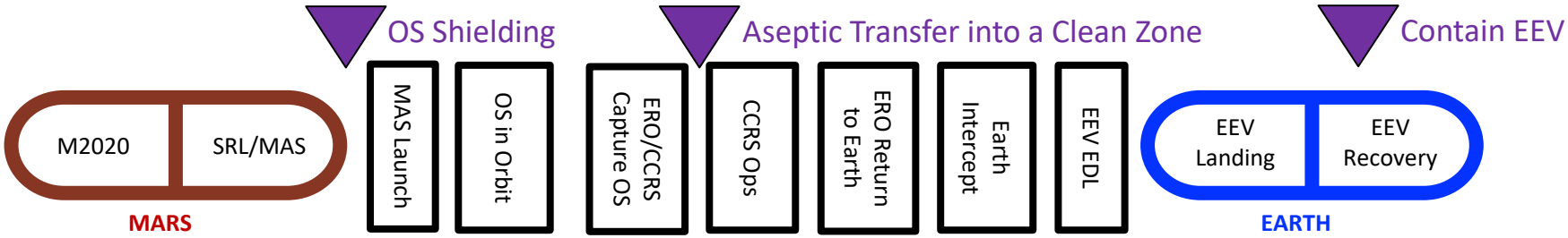
Break the Chain is how we separate Mars material from Earth's biosphere

- Containment Assurance (CA) represents **engineering steps** taken to ensure that Mars material of concern **remains isolated** from Earth

Containment Assurance is how we keep Mars material separate from Earth's biosphere

BTC/CA Engineering Toolset

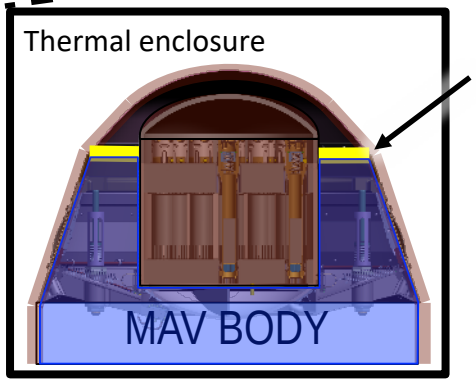
- Break the Chain (BTC) would not be accomplished in a single step
  - Sequential operations reduce quantity of particles transported to next step
  - Engineered BTC features at “pinch points” add extraordinary robustness
- Over five years, the BTC/CA team has explored a broad swath of technologies and techniques to apply to this challenge
- Guidance from Sterilization Working Group (publication forthcoming)
- Three major tools are used in MSR’s BTC/CA architecture
  - Particle Transport Modeling (adhesion, transmission, emission)
  - Particle Containment Technologies (seal, encapsulate, isolate, and block)
  - Particle Sterilization Techniques



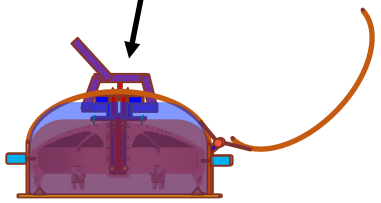
Breaking the Chain with Mars (Concept)

Mars

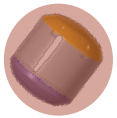
Artist's concept



Barriers enforce clean zones on OS and OS Lid

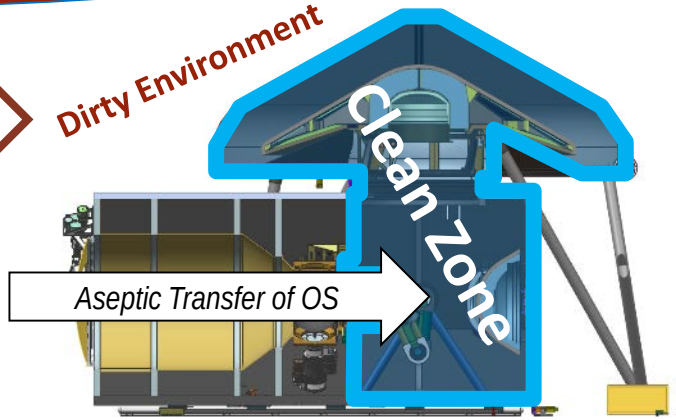


Reduced Particle Load



OS

Artist's concept



Minimize Mars material on ERO (SRL)

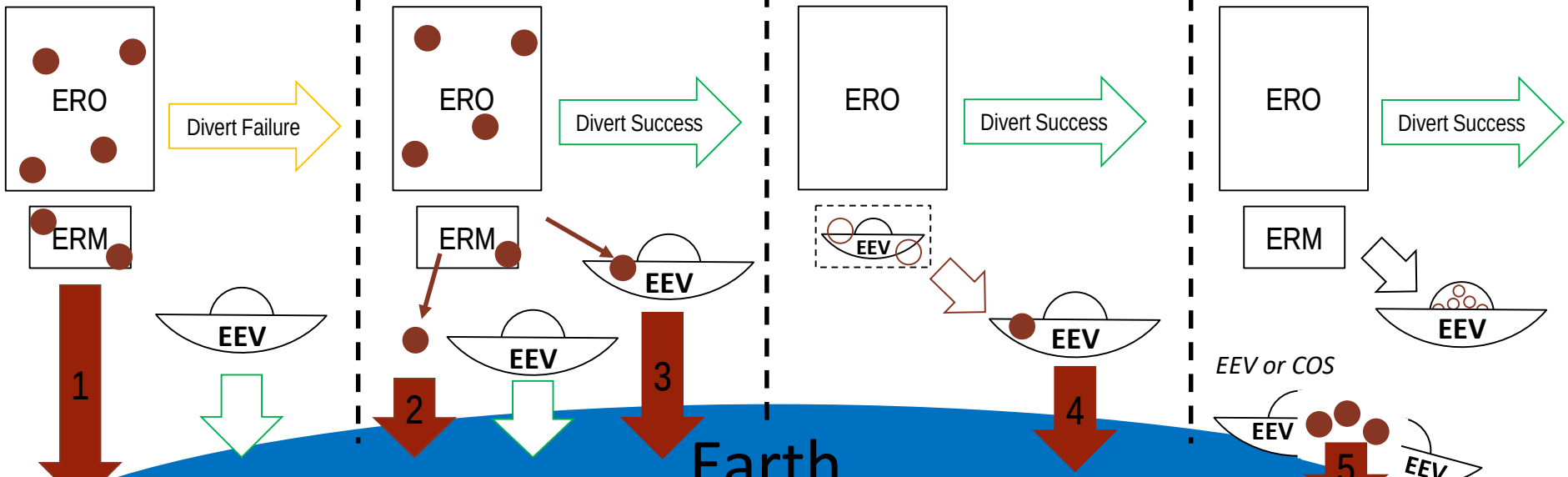
ERO brings material into Earth

ERO emits material to Earth or EEV

Enforce Clean Zone for EEV (CCRS)

EEV is contaminated before release

Containment not assured

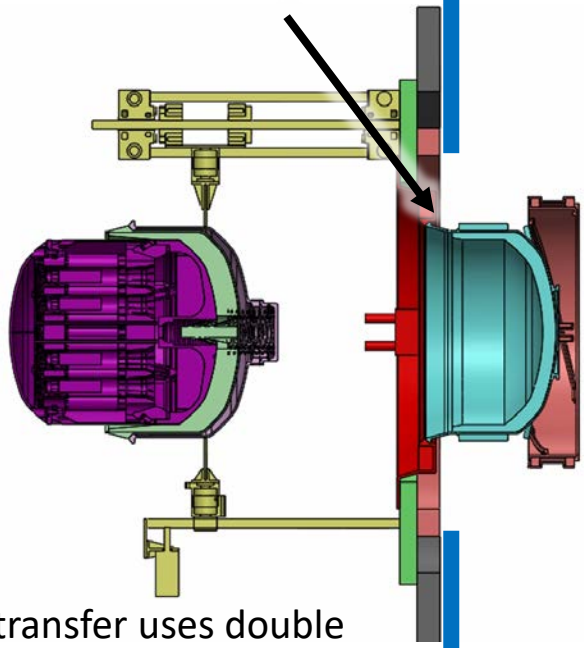


Assuring Containment of Mars Material

Artist's concept

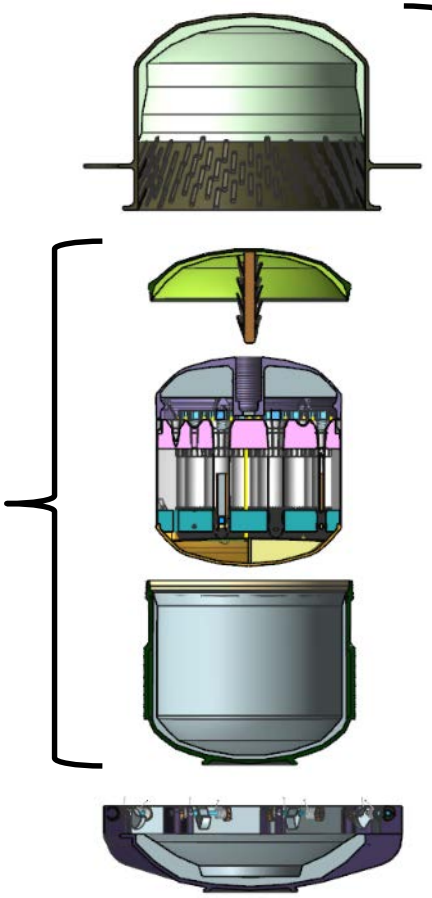
Dirty Environment

Localized heating, titanium PCV shell, and thermal insulation material limit tube temperature increase



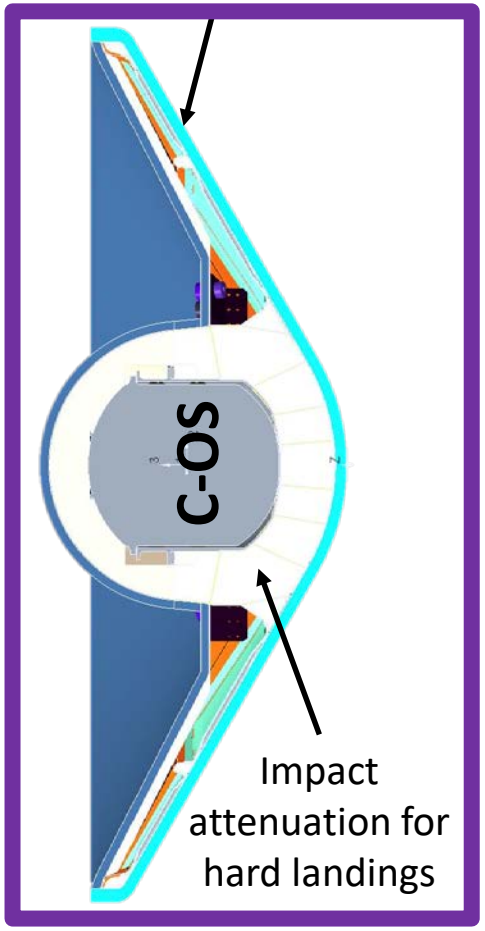
Aseptic transfer uses double walled lid and braze material to seal Primary Containment Vessel (PCV), sterilize its seamline, and block Mars material from entering Clean Zone.

Clean Zone + MMOD Garage



Secondary Containment Vessel provides redundancy, forms Contained OS (C-OS)

HEEET TPS for MMOD resilience



Landing site containment

Passive Earth Entry Vehicle

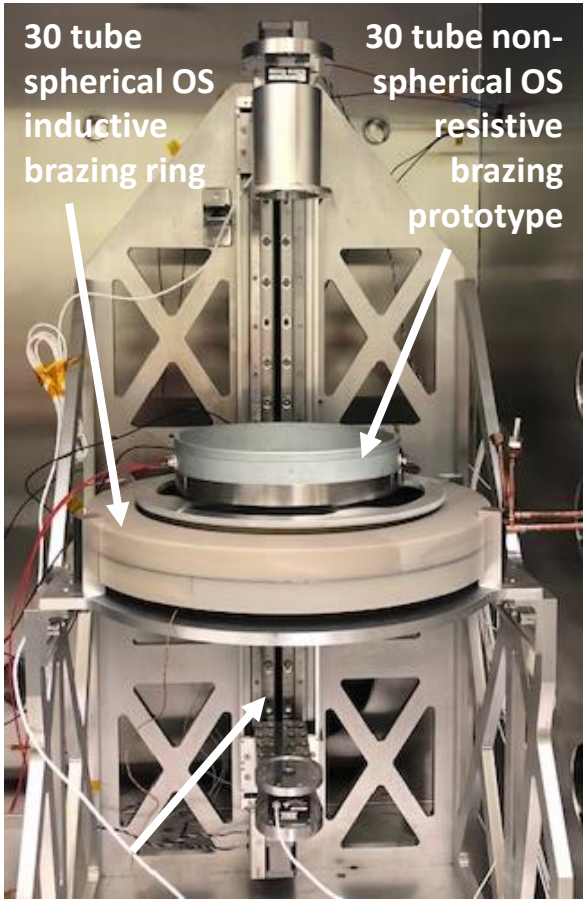
Soft soil preserves science

Off-nominal hard surface

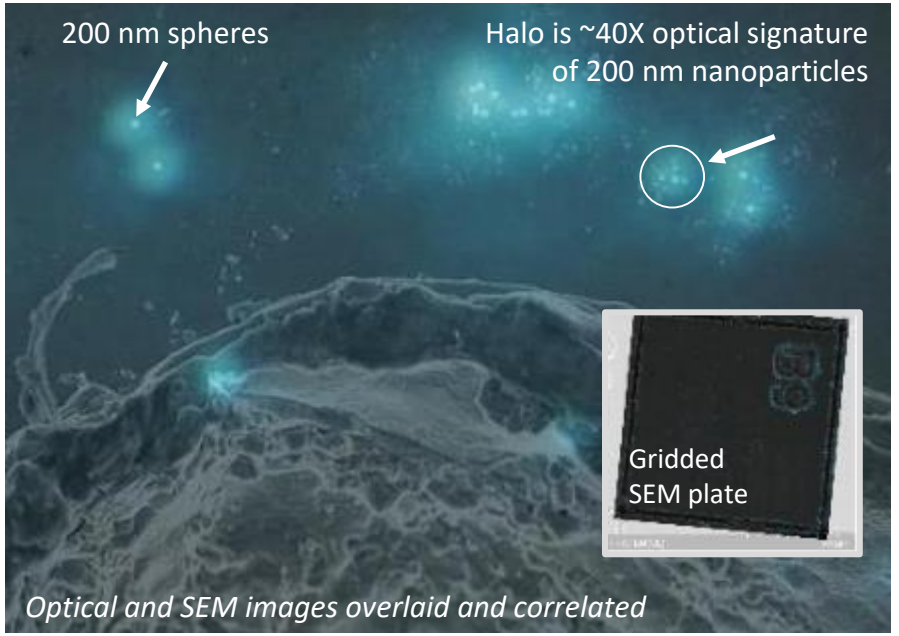
Early Work Building BTC/CA Capability

Right: Full scale inductive brazing testbed (2020 demo) and resistive brazing follow on.

Below: Quarter scale induction testbed, and a selection of sealed and separated shells



Sterilization Working Group at Johnson & Johnson Sterility Assurance, June 2019



JPL developing potential nanoparticle and quantum dot leak tests for V&V (provisional patent)

Work Ahead

- Proceeding with the developing of a multi-pronged strategic approach for BPP implementation across the campaign elements
- Peer review of Break the Chain architecture was held on December
  - Review board included members from NASA HQ, ESA, JPL, GSFC, DARPA, and Dugway Proving Ground
  - MSR Campaign is working with this architecture as a baseline
- Transitioning from technology development to flight team
  - Full scale brazing demonstrations this year
  - Combined C-OS/EEV impact testing late-2021

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