National Aeronautics and Space Administration

NASA/ESA MARS SAMPLE RETURN

Mars Sample Return (MSR)

Mars Exploration Program Analysis Group (MEPAG)
Meeting #40
April 12, 2023

Jeff Gramling, Director, MSR Program

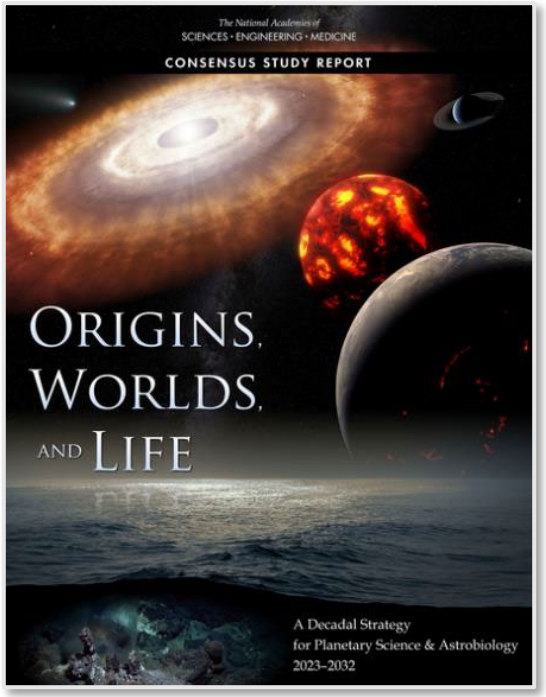
Dr. Michael Meyer, Mars Lead Scientist

The Value of Mars Sample Return to National Goals

"The highest scientific priority of NASA's robotic exploration efforts this decade should be completion of Mars Sample Return as soon as is practicably possible with no increase or decrease in its current scope"

Origins, Worlds, and Life- A Decadal Strategy for Planetary Science and Astrobiology 2023-2032

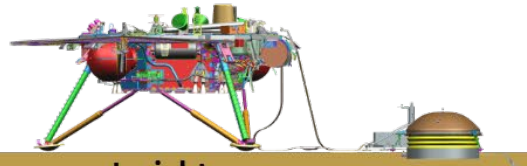
- MSR is our best near-term opportunity to answer the question "Are we alone in the universe?"
  - Mars may have the best record of the first billion years of planetary evolution and life's beginning in the Solar System
- Discovery science - the returned samples will be analyzed in laboratories at universities/research institutes across the world, for decades to come
- The capabilities demonstrated and science returned by the first sample return from another planet will ensure American leadership and pave the way for eventual human exploration of Mars



The Sample Retrieval Lander is a Necessary Step Forward for Our Landing Capability on Mars

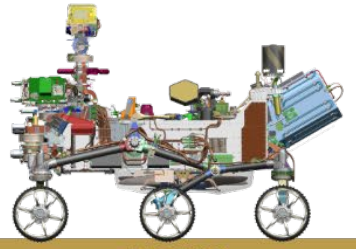
MER

Landed Mass: 500 kg
Rover Mass: 170 kg



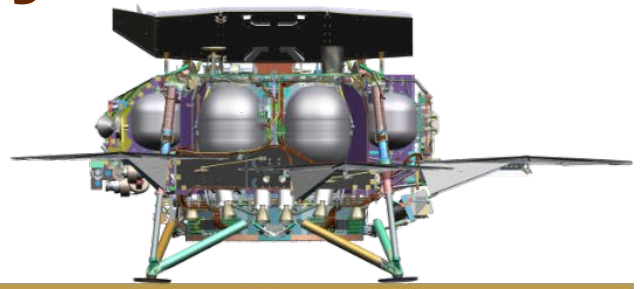
Insight

Landed Mass: 350 kg



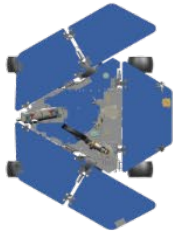
M2020

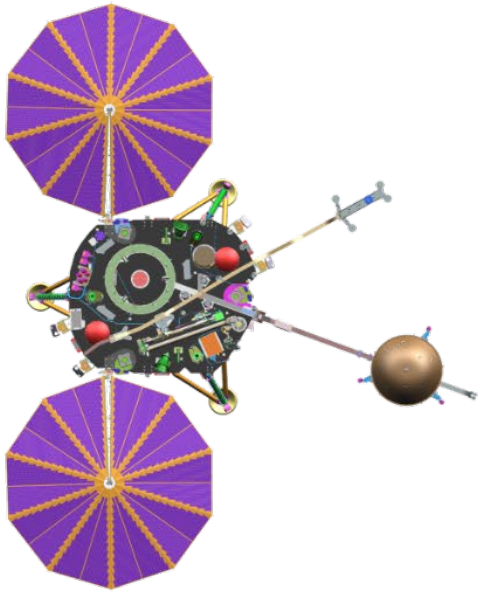
Landed Mass: 1700 kg
Rover Mass: 1000 kg

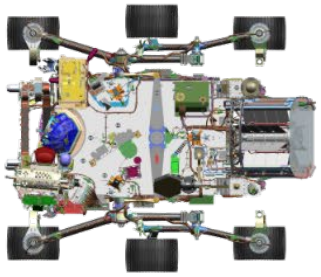


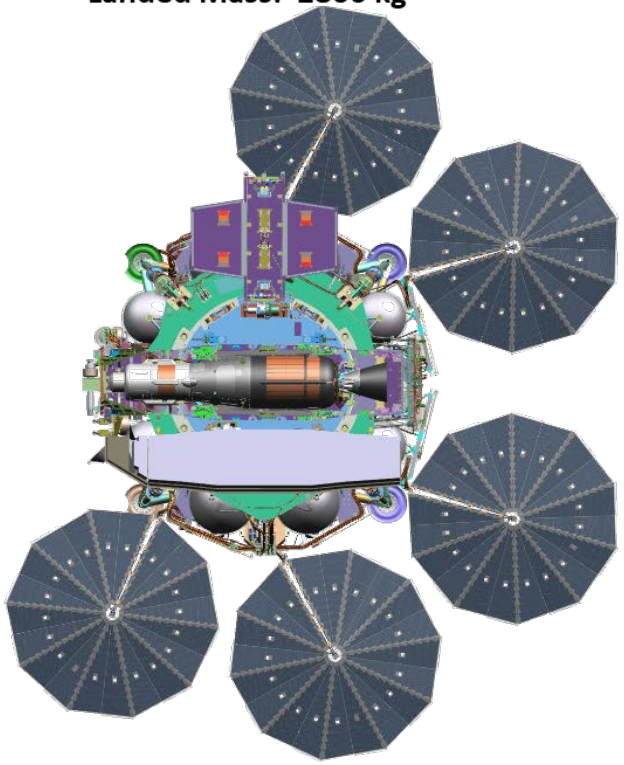
SRL

Landed Mass: 2800 kg









Changes since KDP-A

- Delay of SRL (2028) & ERO (2027) launches from 2026 (Independent Review Board (IRB) recommendation was to delay both to 2028)
- Refine Center roles and reduce organizational complexity (IRB recommendation to reduce organizational complexity)
- Outsourcing Mars Ascent Vehicle (MAV), Earth Entry Vehicle, Sample Retrieval Lander (SRL) Cruise Stage to industry (IRB recommendation to out-source)
- Evaluation and descope of second lander architecture
- Addition of the of Sample Recovery Helicopters (SRH)
- Simplified sample retrieval architecture to baseline direct tube transfer from Perseverance
- Adopted ERO-Below mission design to improve rendezvous robustness & simplify MAV
- Capture Containment and Return System (CCRS) back planetary protection (BPP) approach modified

Key Accomplishments/Risk Reduction

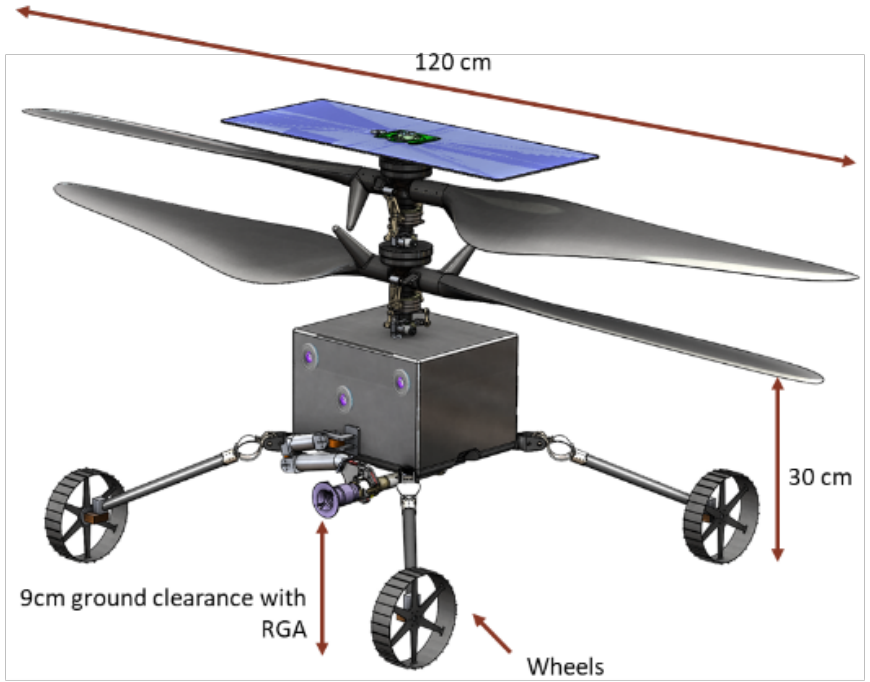
- Establishment of Three Forks cache provides critical mission resiliency against future issues with Perseverance
- Completion of Mars Ascent Vehicle Propulsion System (MAPS) Stage 1, Supersonic Splitline (SSSL) Nozzle: Upcoming Demonstration Motor-1 Hot Fire test demonstrating SSSL Technology Readiness Level 6 (TRL-6) – April 2023
- Drop test of Earth Entry System (EES) mechanical demonstration unit to validate surface impact architecture (no parachute, passive control) completed April 2022
- Completion of expanded Ingenuity flight envelope testing to inform SRH mass capability assessment – February 2023
- Early parachute mortar development testing; Pathfinder parachute constructed (flight-like dimensions and construction)
- Maturing Phase B architecture:
  - Single lander, with addition of Ingenuity based helicopter as a backup sample delivery path to Perseverance
  - Eliminated MAV nosecone
  - Redesigned CCRS robotic arm to simpler gantry type mechanism

Sample Recovery Helicopter (SRH)

- SRH was incorporated into the MSR campaign in mid-2022 replacing the ESA Sample Fetch Rover
  - Backup means for delivery of samples to the Lander
- SRH is derived from the successful Ingenuity technology demonstration on the M2020 mission
- Vacuum chamber testing of an engineering model completed end-February to demonstrate the SRH capability to retrieve samples cached on the surface by Perseverance
- Tested a range of parameters from within the design envelope (a combination of changes from Ingenuity heritage)
  - Design changes from Ingenuity include extension of rotor to 1.4m diameter, increased rotor speed, and higher angle of attack to support the 2.5kg mass requirement

Ingenuity-like rotorcraft with:

- Ground mobility
- Tube manipulator
- Stereo vision
- Inflight, absolute localization



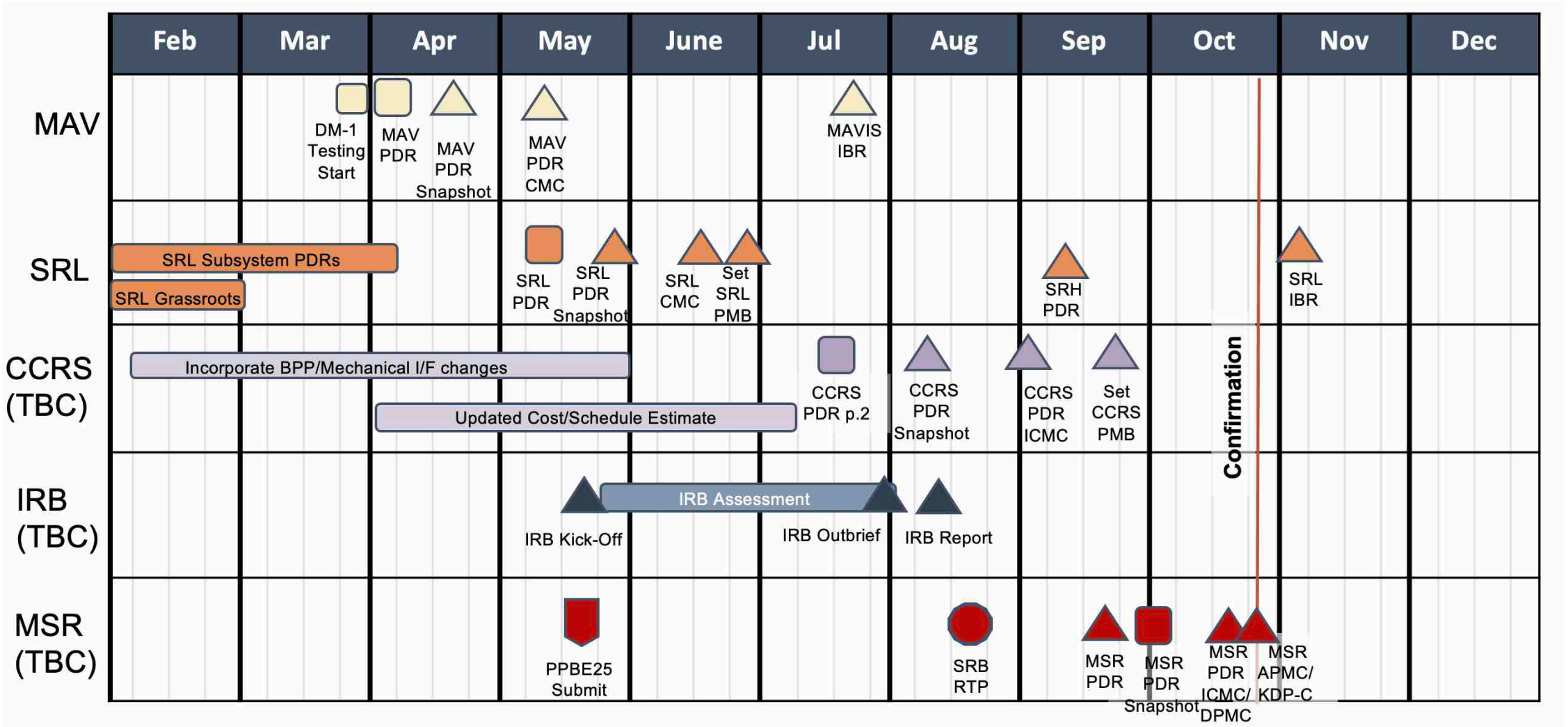
FY24 President's Budget Request

- To maintain progress in FY24 towards earliest possible launch date, FY24 budget request is $949.3M
  - SRL launch as early as 2028, ERO/CCRS launch as early as 2027, with sample return as early as 2033
- Program will validate Cost and Schedule baseline through independent review and estimates prior to Agency Confirmation at KDP-C
- Descope options cited include potentially one helicopter

Independent Review Board (IRB)

- SMD is commissioning a second program IRB to review the Program prior to Confirmation
- Complement and achieve degree of overlap with SRB to reduce learning curve and ensure carry-forward of findings, including OCFO cost/schedule continuity
- Timeline: 6-8 weeks, between Program Element PDRs and Program PDR
- The IRB's objectives and scope are derived from the MSR Pre-Phase A IRB convening memo, and updated to address focused questions bearing on Confirmation for a complex and distributed program such as MSR
- IRB will provide independent review of program's readiness for Confirmation

MSR Planned Path to Confirmation



What Makes MSR So Valuable?

Four powerful technical advantages:

Access to sophisticated sample preparation

- *Reduces detection limits (by orders of magnitude)*
- *Improves precision*
- *Improves accuracy*
- *Required for many instruments and analyses*

Varied and complex organic preparation pathways

Access to a wide variety of complex and large instruments that cannot be miniaturized

- *Opportunity to make confirming measurements using multiple methods*
- *"Gift that keeps on giving" – analysis by future instruments and techniques that do not exist yet*
- *"Extraordinary claims require extraordinary evidence"*

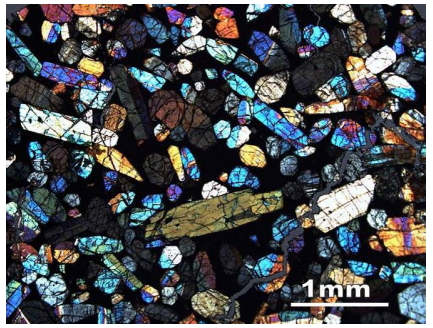
Scanning Electron Microscope

Discovery-responsive investigation pathways

- *Answers to early questions change choice/design of later experiments*
- *Ability to address questions in the future that have not yet arisen in the context of current knowledge*

Thin section of a Cretaceous oolitic limestone

Access to high analytical precision, high spatial resolution



- *Microscopic scale (high spatial resolution) analyses are crucial for evaluating microbial life*
- *Highest precision isotopic analyses for best possible age determinations*

Thin section of Mars meteorite
Under cross polarized light

MSR Campaign Science

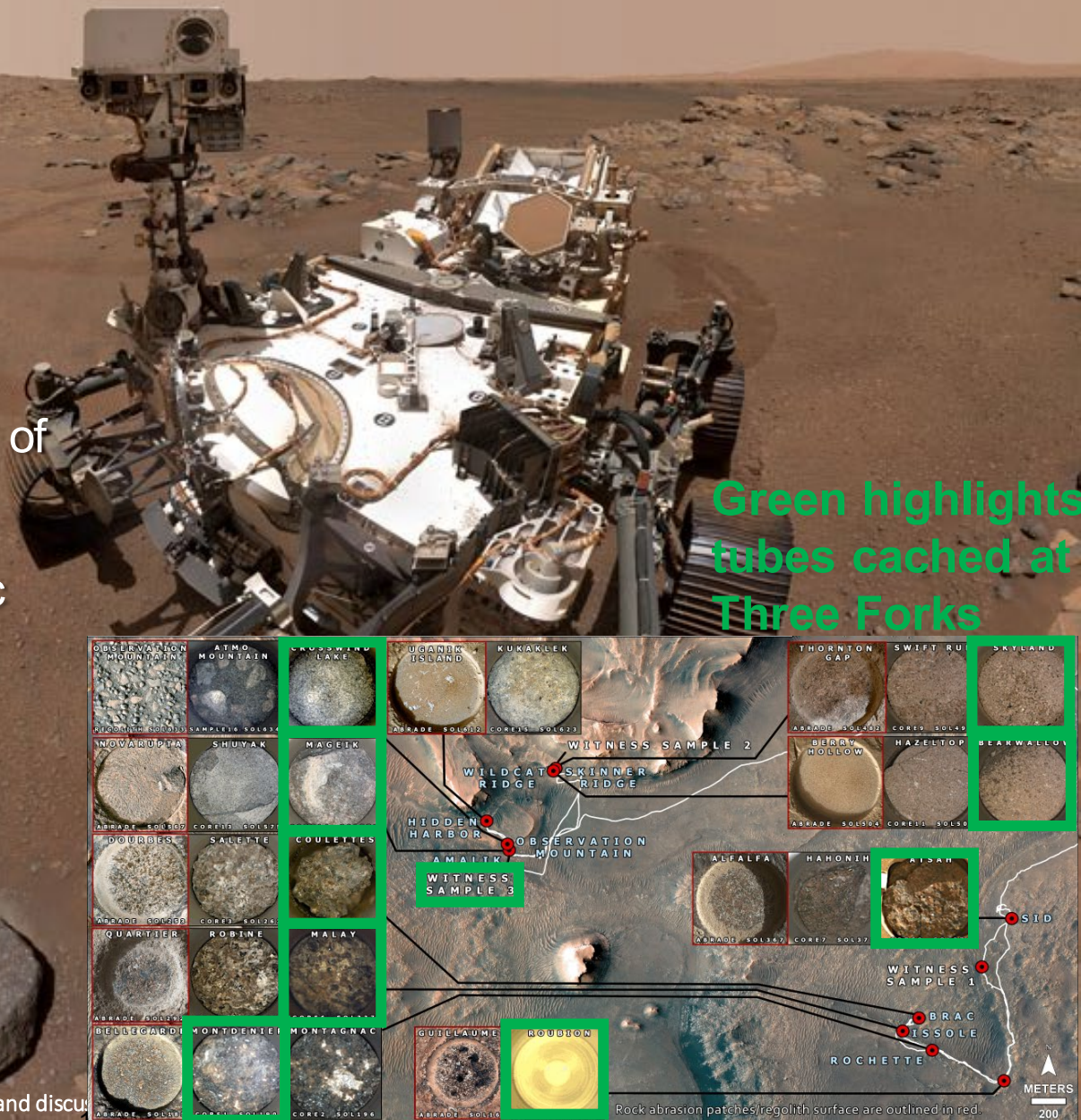
Science Links All Elements of Campaign

Mars Sample Return Program

1	2	3	4
			
Mars 2020 Sample Caching	**Sample Retrieval Lander (SRL)**	**Earth Return Orbiter (ERO)**	**Sample Receiving Project**
• *Collect samples of rock, regolith, and atmosphere* • *Cache samples on the surface for retrieval*	• *Retrieve samples cached by Mars 2020 rover* • *Launch samples into orbit around Mars*	• *Capture and contain samples in Mars orbit* • *Safely return samples to Earth for recovery at landing site*	• *Recover and transport contained samples to receiving facility* • *Safety assessment and sample containment* • *Initial sample science and curation*

High Priority MSR Science Objectives Can be Addressed by Samples Collected So Far:

- ✓ Igneous rocks from the crater floor: absolute ages of units in Jezero crater to anchor the ages of Martian epochs; magmatic evolution on Mars
- ✓ Sedimentary rocks from the delta front: promising target for the search for evidence of ancient life
- ✓ Aqueous alteration products: insights into the history of near-surface water in this region of Mars
- ✓ Likely presence of organics: deduce origins (biogenic vs. abiogenic)
- ✓ Samples will also address gaps in our knowledge of concern to future human exploration



Campaign Science Update

- MSR Campaign Science Group (MCSG) led Science Community Workshop that assessed the initial cache as return worthy and endorsed which of the paired samples were to be left at Three Forks. All seven of the iMOST objectives can be addressed by the samples in this depot.
- MCSG met at Centro de Astrobiología (CAB) on Feb 21-23 to discuss future science investigations and Sample Receiving Project (SRP), including deliverables for SRP Mission Concept Review, instrument list for the facility, scope of Measurement Definition Team, sample extraction processes, and potential R&D.
- Next Opportunity for Science Community Involvement: Open call for membership on the Measurement Definition Team (MDT) to develop a strawman set of instruments that would be needed within the high-containment facility to accomplish sample safety assessment, curation, and science.
  - The call will be soon and, after selection, will be commissioned for approximately six months.
  - To receive the latest and timely information for applying to be a member of the MDT, register your interest at: https://science.nasa.gov/solar-system *(link title: Mars Sample Receiving Project Measurement Definition Team 1 - Indication of Interest)*
    - *>750 people have registered interest*

Backward Planetary Protection (BPP) Implementation

- MSR is the first mission to implement challenging “break-the-chain” BPP method
- Employs redundancy for breaking the chain of contact with Mars
  - The system is tolerant to the failure of any one of three protective elements: a primary container, sterilization of the container exterior, and a secondary containment vessel
  - The samples (~500 g) collected by Perseverance would be further protected within hermetically sealed sample tubes, in addition to the primary and secondary containment vessels
- MSR approach to BPP to manage <20 mg of uncontained aeolian dust exterior to the Orbiting Sample (OS) container that:
  - Recognizes the very low potential hazard of subcellular entities to Earth’s biosphere
  - Uses an alternative sterilization process (UV) for cellular entities that reduces risk to sample integrity (vs. heat)
  - Less complex implementation should enhance reliability
- BPP approach is consistent with NASA and international BPP policies to achieve a very low risk of harm to Earth’s biosphere from sample return
- Independent review of this approach will be accomplished through:
  1) Independent panel review of MSR’s approach to subcellular entities and UV sterilization—commissioned by NASA Office of Chief Scientist
  2) Testing of UV sterilization efficacy in CCRS environment

Summary

- "Perseverance has gathered a scientifically stunning set of rocks." Nature April 3, 2023
- MSR is a complex and challenging mission in response to the Decadal Survey endorsement to return the scientifically-compelling samples being collected
  - The science provided as a result of the mission would lay the foundation for the success of human exploration of Mars
- This international collaboration between NASA and ESA, which leverages the strengths of seven NASA field centers (JPL, GSFC, MSFC, LaRC, ARC, JSC, and KSC) and more than 20 industry partners, is focused on completing the work necessary to conduct the program Preliminary Design Review in advance of the Confirmation decision
- The Sample Receiving Project (SRP) established at Johnson Space Center is preparing for Mission Concept Review and working with the science community to define future science investigations and needed instrumentation