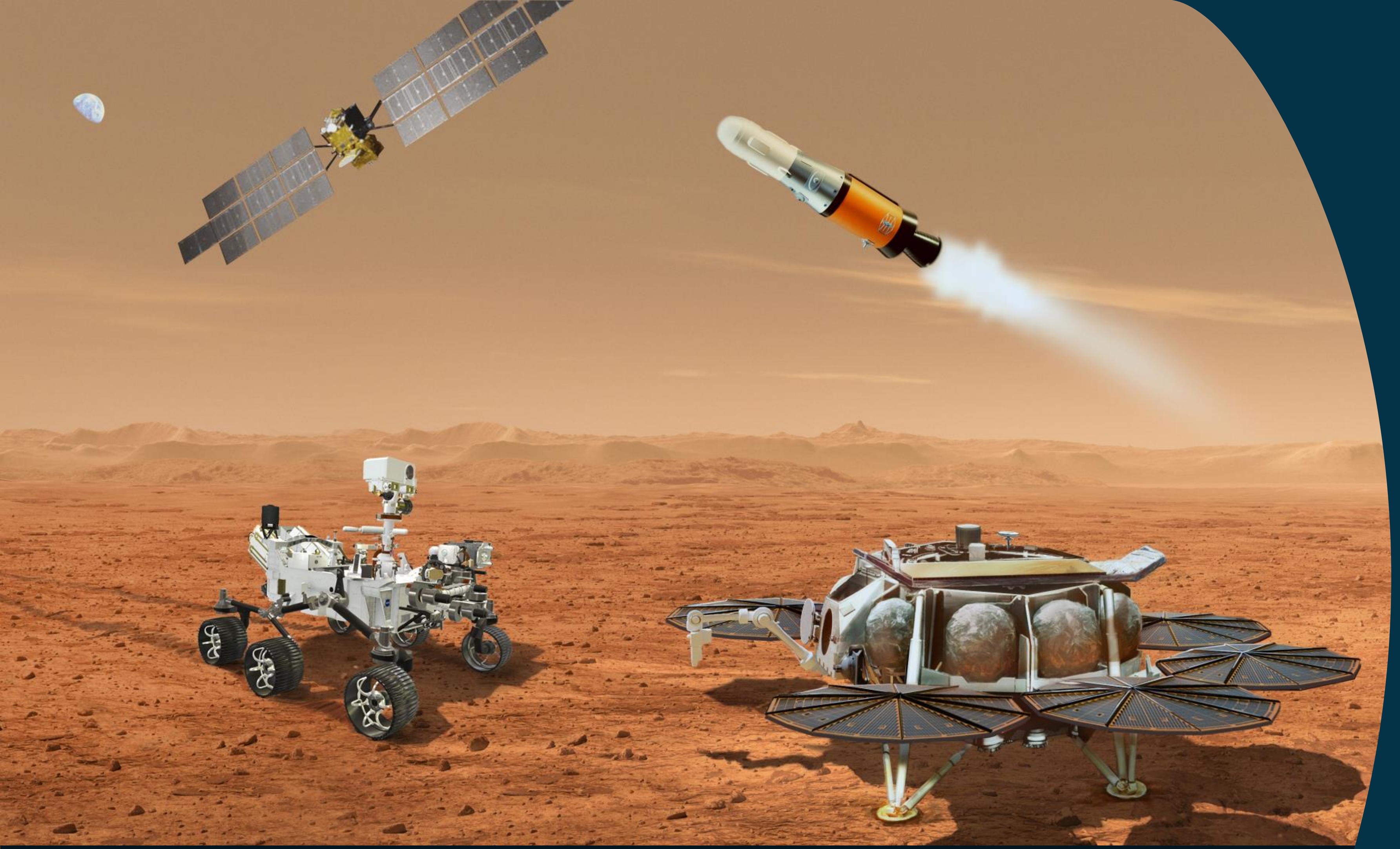


NASA/ESA MARS SAMPLE RETURN

NASA Response to MSR Independent Review Board Report & MSR Status

Committee on Astrobiology & Planetary Sciences (CAPS)

MSR Program Director, Jeff Gramling
MSR Deputy Program Director, Donya Douglas-Bradshaw
Senior Scientist for Mars Exploration, Dr. Lindsay Hays

October 21, 2024

MSR- Path to Confirmation

Mars Sample Return Campaign (Reference Architecture)

MEP

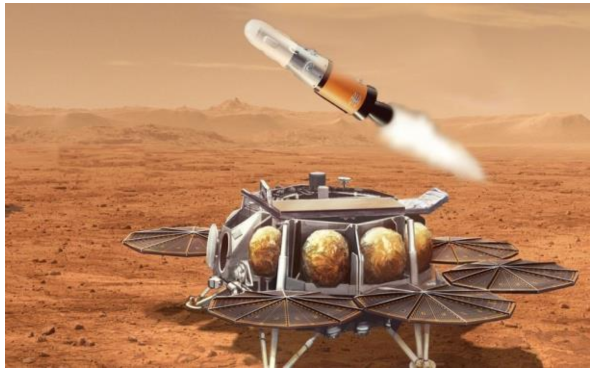
Mars Sample Caching

Perseverance Rover

- *Operational on Mars since 2021*
- *Collect samples of rock, regolith, and atmosphere*
- *Cache samples on the surface for retrieval*

MSR PROGRAM

Sample Retrieval Lander & Launch Vehicle



Sample Retrieval Lander (SRL)

Mars Ascent Vehicle (MAV)

Sample Transfer Arm (STA)

Orbiting Sample (OS)

- *Retrieve samples cached onboard Mars 2020 rover*
- *Launch samples into orbit around Mars*

Earth Return Orbiter

Earth Return Orbiter (ERO)

Capture, Containment, and Return System (CCRS)

- *ESA provides the orbiter, NASA provides the capture system*
- *Capture and contain samples in Mars orbit*
- *Decontamination, Back Planetary Protection (BPP)*
- *Safely return samples to Earth for recovery at landing site*

MEP

Sample Recovery, Transport, & Curation

Sample Receiving Project

- *Recover and transport contained samples to receiving facility*
- *Safety assessment and sample containment*
- *Initial sample science and curation*

MEP – Mars Exploration Program
MSR – Mars Sample Return

Forward from IRB-2: SMD’s MIRT Recommendations

- ❑ Revise MSR mission design with improved resiliency, risk posture, and reduced complexity
  - Maintain NASA’s MSR Memorandum of Understanding with ESA and launch Earth Return Orbiter(ERO)/Capture Containment and Return System(CCRS) in 2030, launch Sample Retrieval Lander(SRL)/Mars Ascent Vehicle (MAV) from Earth in 2035, and return samples to Earth in 2040
  - Returns carefully selected, diverse samples collected by Perseverance
  - Balances programmatic and technical risk, and decouples launch readiness dates
  - Adds a Radioisotope Thermoelectric Generator (RTG) to SRL to improve reliability and MAV thermal environment
  - Refreshes telecommunications prior to SRL arrival
  - Provides more time to mature SRL and MAV designs
  - Finalizes Orbiting Sample design early to stabilize overall mission design
  - Parametric Lifecycle Cost estimate of $8-11B, and is consistent with IRB-2
  - Improve lines of accountability and authority
    - Keep the Mars Exploration Program (MEP) and Mars Sample Return (MSR) as separate programs ✅
    - Empower the NASA HQ MSR Program Office with all programmatic capabilities including system engineering and Program Planning & Control (PP&C) responsibilities ✅
    - Elevate Mars Ascent Vehicle (MAV) and Mars Orbiting Sample system (OS) to Level 2 Projects ✅
    - Establish Standing Review Boards (SRBs) for the MSR Program and MSR Level 2 Projects ✅

Forward from IRB-2: SMD's MIRT Recommendations (Cont’d)

- ❑ Improve communications and coordination within the Agency and with external stakeholders
  - Expand the frequency of engagement between the MSR Program Director (PD) and NASA Senior Leadership ✅
- ❑ Competitively select one world-class Mars Chief Scientist to span MEP and MSR ✅
- ❑ Explore out-of-the-box architecture and mission element options by releasing a competitive industry study solicitation as soon as possible. ✅
  - Innovative or alternate architectures could offer lower overall cost, lower annual cost, earlier sample return, and/or less complex/lower risk.
  - Since OS and MAV drive overall mission size, complexity, and cost, studies should include alternative MAV designs.
  - In parallel, engage with NASA Centers and JPL for additional out-of-the-box architecture solutions.
  - The architecture must be capable of returning samples collected by Perseverance from the surface of Mars to Earth

Mission Design Studies

- 48 industry proposals received
- 12 studies (JPL, APL/WFF, Internal NASA Team, MSFC and 8 industry)
- Final reports received October 15

- End-to-End Mission Architecture
  - Lockheed Martin
  - SpaceX
  - Blue Origin
  - Rocket Lab
  - Jet Propulsion Laboratory
  - NASA Internal Team
- Smaller/Lower Mass MAV
  - Aerojet Rocketdyne
  - Northrup Grumman
  - Whittinghill Aerospace
  - Applied Physics Lab/ Wallops Flight Facility
  - Marshall Space Flight Center
- Cis-Lunar Return Architecture
  - Quantum Space

From Studies to Go-Forward Architecture: MSR Strategy Review

- NASA has established a MSR Strategy Review (MSR-SR) team chaired by former NASA Administrator, Hon. Jim Bridenstine and consisting of scientific and technical experts to evaluate the 12 studies and recommend a go-forward architecture that provides the highest likelihood of returning samples to Earth before 2040 and/or for less than $11B
  - The MSR-SR team will present its findings and go-forward architecture recommendation to the SMD Associate Administrator, Dr. Fox
  - In the December timeframe, the SMD AA will propose a recommended go-forward architecture to the Administrator for agency approval

- **Degree of complexity**: A less complex mission design that results in reduced risk, cost, and/or schedule is desired.
- **Total cost to NASA**: Reduced total cost to NASA is desired. For industry-provided concepts, NASA will add the costs associated with any proposed Government Furnished Equipment (GFE) to calculate the total cost to NASA.
- **Annual affordability by NASA**: A lower peak for the cost profile is desired to maintain a balanced portfolio. For industry-provided concepts, NASA will overlay the cost profile for any GFE elements.
- **Date of sample return to Earth**: Earliest possible return date is desired.
- **Number and scientific value of samples returned**: As many scientifically valuable samples as possible returned is desired. A mission design should deliver at least 10 samples to Earth. Samples currently being carried by the Perseverance rover are considered of greater scientific value than the samples at the Three Forks Depot.

Strategic Review Members

Strategic Review Team

Chair: Hon. Jim Bridenstine, former NASA administrator

Phil Christensen, Ph.D., Regents' Professor, School of Earth and Space Exploration, Arizona State University, Tempe

Jack Mustard, Ph.D., Professor of Earth, Environmental, and Planetary Science, Brown University

Maria Zuber, Ph.D., E. A. Griswold Professor of Geophysics, MIT. Presidential Advisor for Science and Technology Policy

Lisa Pratt, Ph.D., former NASA Planetary Protection Officer

Greg Robinson, former Director, James Webb Space Telescope Program

Steve Battel, President, Battel Engineering; Professor of Practice, University of Michigan, Ann Arbor

Eric Evans, Ph.D., Director Emeritus and Fellow, MIT Lincoln Lab

The MSR-SR Team may request technical, scientific, and programmatic support and analysis from the NASA Analysis Team (NAT) comprised of government employees and expert consultants

NASA Analysis Team (NAT) Members

Lead: Dave Mitchell, Agency Chief Program Management Officer

Ellen Stofan, Ph.D., Under Secretary for Science and Research, Smithsonian

Steve Creech, Assistant Deputy Associate Administrator for Technical, Moon to Mars Program Office, Headquarters

Rob Manning, Chief Engineer emeritus, Jet Propulsion Laboratory

Mike Menzel, JWST Lead Mission Systems Engineer, Goddard Space Flight Center

Fernando Pellerano, Senior Advisor for Systems Engineering, Goddard Space Flight Center

Ruth Siboni, Chief of Staff, Moon to Mars Program Office, Headquarters

Bryan Smith, Director of Facilities, Test and Manufacturing, Glenn Research Center

John Aitchison, Program Business Manager (acting), Mars Sample Return, OCFO/Headquarters

Brian Corb, Control/Schedule Analyst

Mark Jacobs, Senior Systems Engineer

MSR Program Leadership


Jeff Gramling
Director


Donya Douglas-Bradshaw
Deputy Director


Dr. Lindsay Hays
Senior Scientist for Mars Exploration


Rich Ryan
Deputy Director for Business


Steve Thibault
Chief Engineer


Aaron Decker
Chief Safety and Mission Assurance Officer

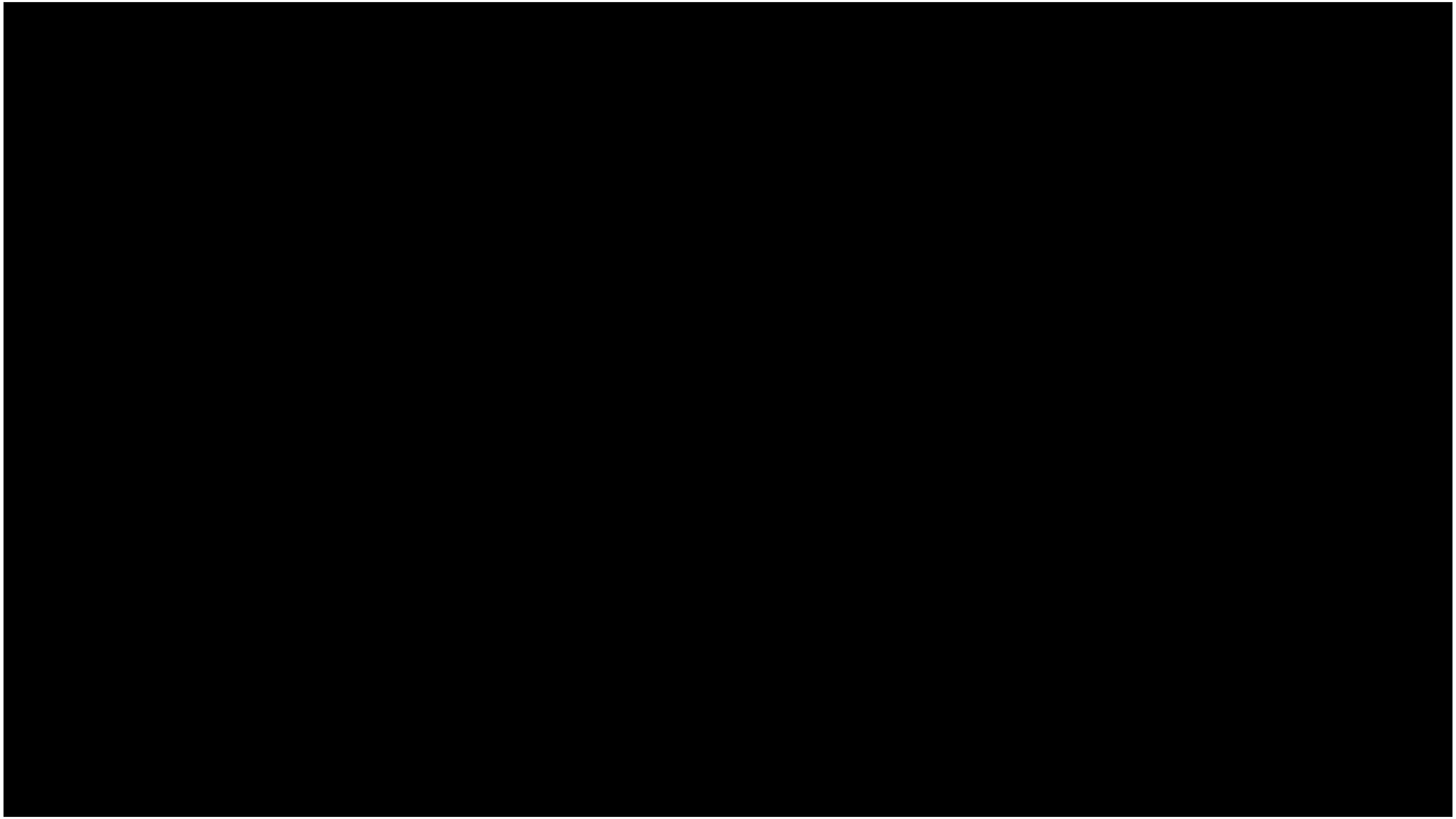
Mars Sample Return Campaign Science


MARS 2020
PERSEVERANCE
1,000 days on Mars
Perseverance Odometer: 37.78 km*
Ingenuity Log: 72 flights, 17 km
* As of October 17, 2024
Margin Campaign
Delta Top Campaign
Crater Rim Campaign
Pico Turquino
Three Forks
Sol 382
Octavia E. Butler Landing Site
Crater Floor
Screenshot
Map Scale
0
500m
1000m
2km

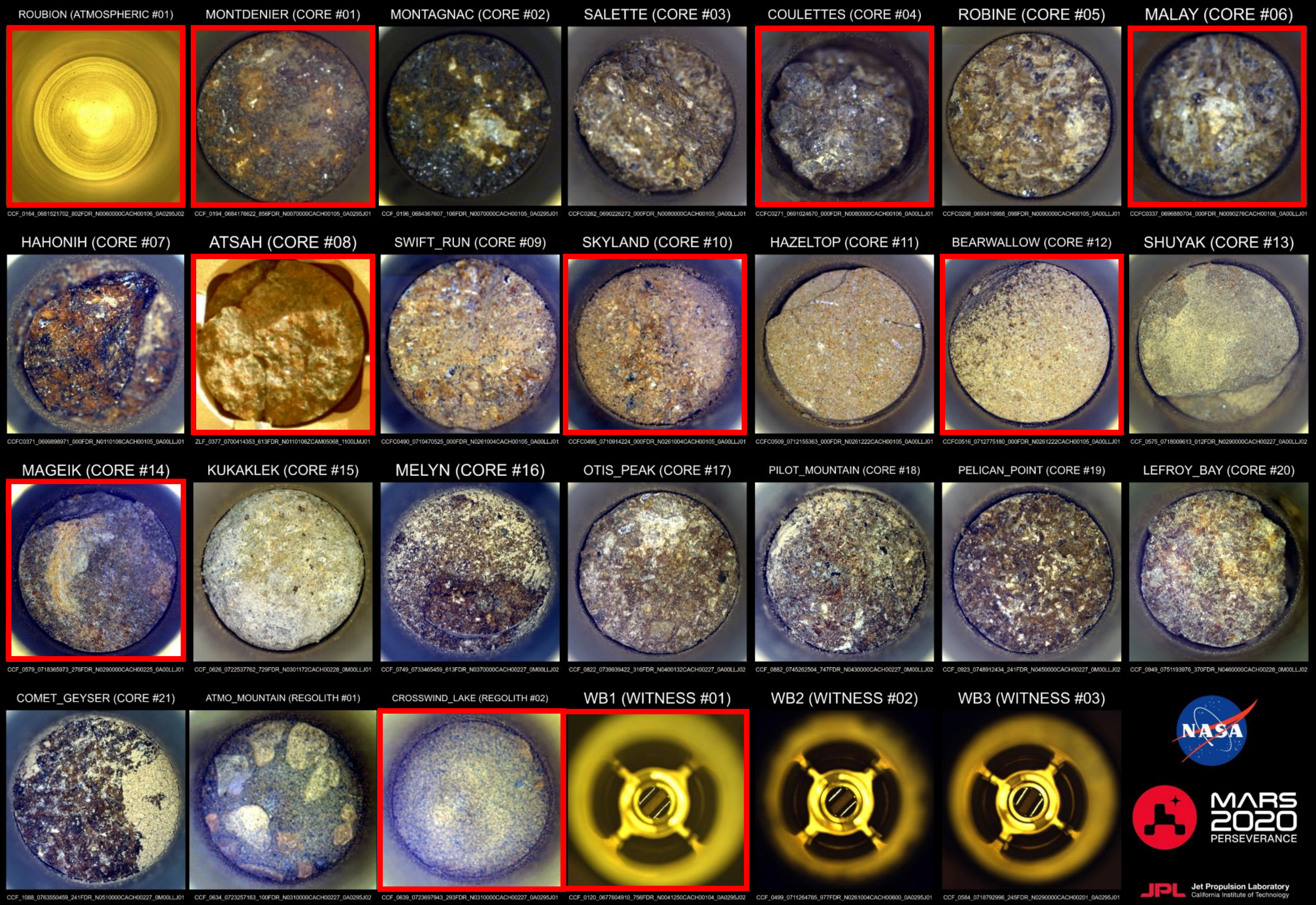
Crater Rim Climb

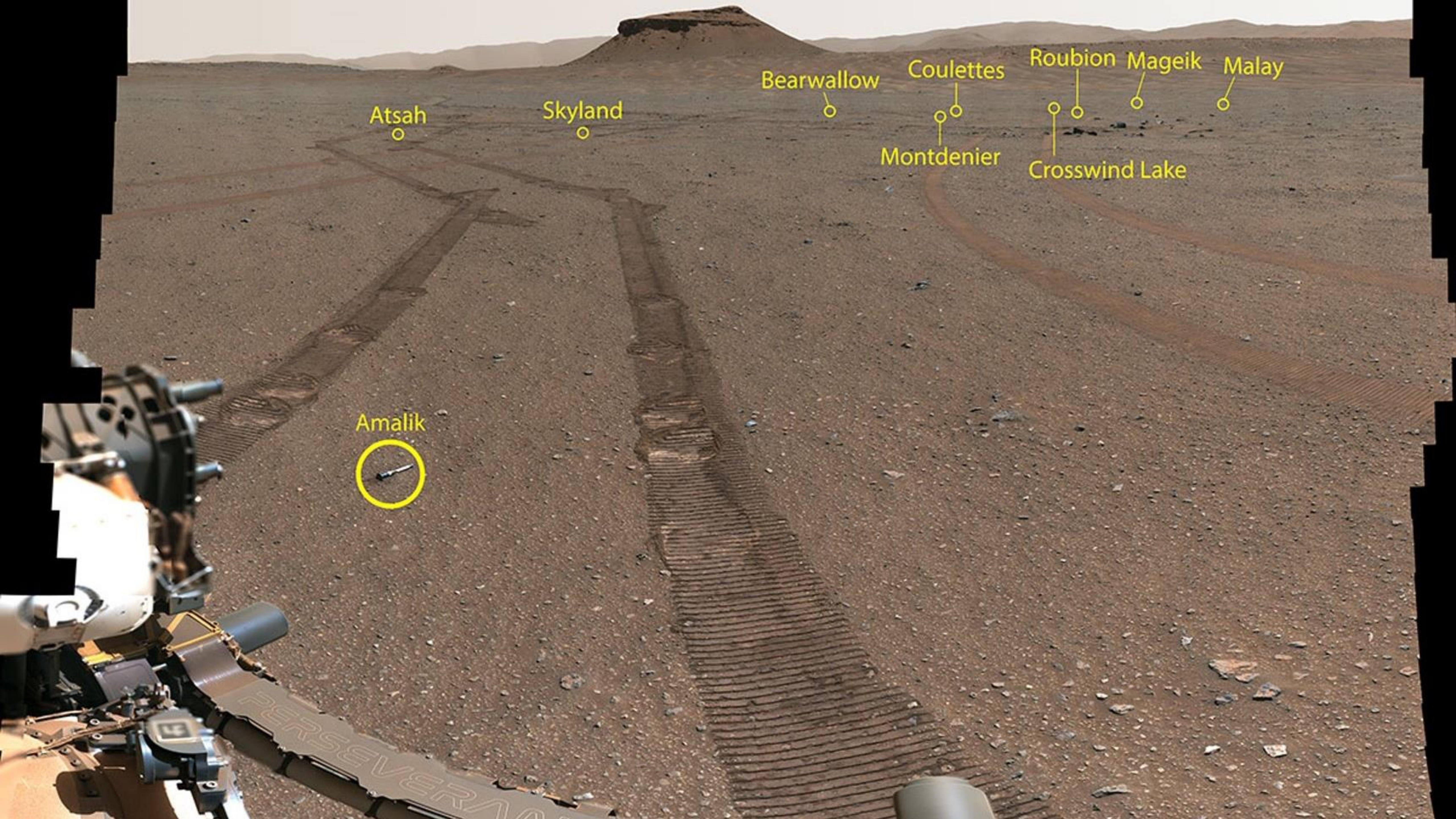
Sol 382 from Mastcam-Z image, taken from East side of Seitah (not far from landing site)

Unveiling Mars' Secrets, One Sample at a Time



Mars 2020 Sample Collection - Jezero Crater (4 July 2024)




Atsah
Skyland
Bearwallow
Coulettes
Montdenier
Roubion
Crosswind Lake
Mageik
Malay
Amalik
PERSEVERANCE

Sample Science Traceability to iMOST and M2020 Objectives

iMOST Objectives (Shorthand)	WTA b*	Sample 1 (Rubion) ATM	Samples 2&3 (Rochette) *Basaltic Ign. Cores*	Samples 4&5 (Brac) *Cumulate Ign. Cores*	Samples 6&7 (Issole) *Cumulate Ign. Cores*	Samples 8&9 (Sid) *Basaltic Ign. Cores*	Samples 10&11 (Skinner Ridge) *Coarse Detrital Sedim. Cores*	WTA 1	Samples 12&13 (Wildcat Ridge) *Fine Detrital Sedim. cores*	Samples 14&15 *TBD (fine?)*	WTA 2	*Samples 16&17 TBD (Regolith?)*
	Crater Floor Campaign						*Delta Front Campaign*					
1. Geol. Environ. (Jezero)												
1.1 Sedimentary System	○	○	○	○	○	○	●	○	◐	◐	○	◐
1.2 Hydrothermal	○	○	◐	◐	◐	◐	○	○	○	○	○	○
1.3 Deep groundwater	○	○	◐	◐	◐	◐	○	○	○	○	○	○
1.4 Subaerial	○	◐	◐	◐	◐	◐	●	○	●	●	○	◐
1.5 Igneous terrain	○	○	●	●	●	●	●	○	○	○	○	●
2. Life												
2.1 Carbon/organic chem.	◐	○	◐	◐	◐	◐	●	◐	◐	◐	◐	◐
2.2 Ancient hab./biosig.	◐	◐	◐	◐	◐	◐	●	◐	●	●	◐	●
2.3 Modern hab./biosig.	◐	◐	●	●	●	●	●	◐	●	●	◐	●
3. Geochronology	○	○	●	●	●	●	●	○	○	◐	○	◐
4. Volatiles	●	●	◐	◐	◐	◐	◐	●	○	○	●	◐
5. Planetary Scale Geol.	○	○	◐	◐	◐	◐	◐	○	◐	◐	○	○
6. Environmental hazards	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	◐	●
7. ISRU	○	◐	○	○	○	○	◐	○	◐	◐	○	◐

*Bit Carousel Witness Tube Assembly (WTAb) activated pre-launch and sealed on Mars on Sol 120, contamination exposure much longer than sample tubes and ordinary WTAs. WTAs alone won't directly address objectives, but serve as an important control for iMOST Objectives 2 and 4. Possibility of also achieving some Mars atmospheric science objectives with a WTA currently under study.

With anticipated analyses, iMOST key MSR questions: ● can be fully addressed; ◐ can be partially addressed; ○ cannot be addressed

Pre-Decisional - for planning and discussion purposes only.

Science Community Virtual Workshop:

MSR Sample Receiving Project Science Goals

- Held Sept 11, 2024
- Open to the science community with two goals:
  - Review proposed revisions by the Mars Sample Return Campaign Science Group (MCSG) to the MSR SRP Science objectives
  - Review proposed compelling science investigations mapped to the MSR SRP science objectives by the SRP Measurement Definition Team

SRP Draft Science Goals Preamble

The analysis of returned samples from Mars is unprecedented. The Sample Receiving Project will support detailed scientific investigations, both within and outside of containment, to advance our understanding of Mars' geologic and astrobiological history at a resolution never before possible. These investigations will combine a broad array of advanced laboratory instruments and sample preparation methods to gain a greater understanding of chemical composition and diversity and examine small-scale features from known geologic contexts at higher sensitivity, lower detection limits, and finer spatial resolution than ever before. The knowledge gained by analyzing the MSR samples, and comparisons with the data from spacecraft and meteorites, will allow us to greatly enhance our scientific understanding of Mars, planetary bodies, and the Solar System as a whole.

Science Receiving Facility Draft Science Goals

#	SHORT-HAND	FULL GOAL STATEMENT
1	Geologic History	Reconstruct the formation and alteration history of the returned samples to transform our understanding of the geological processes and environments of Mars
2	Astrobiology	Determine the astrobiological significance of the martian geological record represented by the samples.
3	Planetary Evolution	Provide new insights into planetary-scale formation and evolution of Mars and other terrestrial bodies.
4	Science for Future Human Missions	Identify and characterize potential risks and opportunities for future human missions.

The Importance of MSR

- Culmination of Over Five Decades of Science at Mars
- Addressing High Priority Science Questions
- Contributing to Global Science
- Paving the Way for Future Science

Back-Up