National Aeronautics and
Space Administration

EXPLORE MARS

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NASA Planetary Science Advisory Committee (PAC) Meeting
February 2023

Mars Exploration Program Highlights

Perseverance completed deployment of the Three Forks cache!

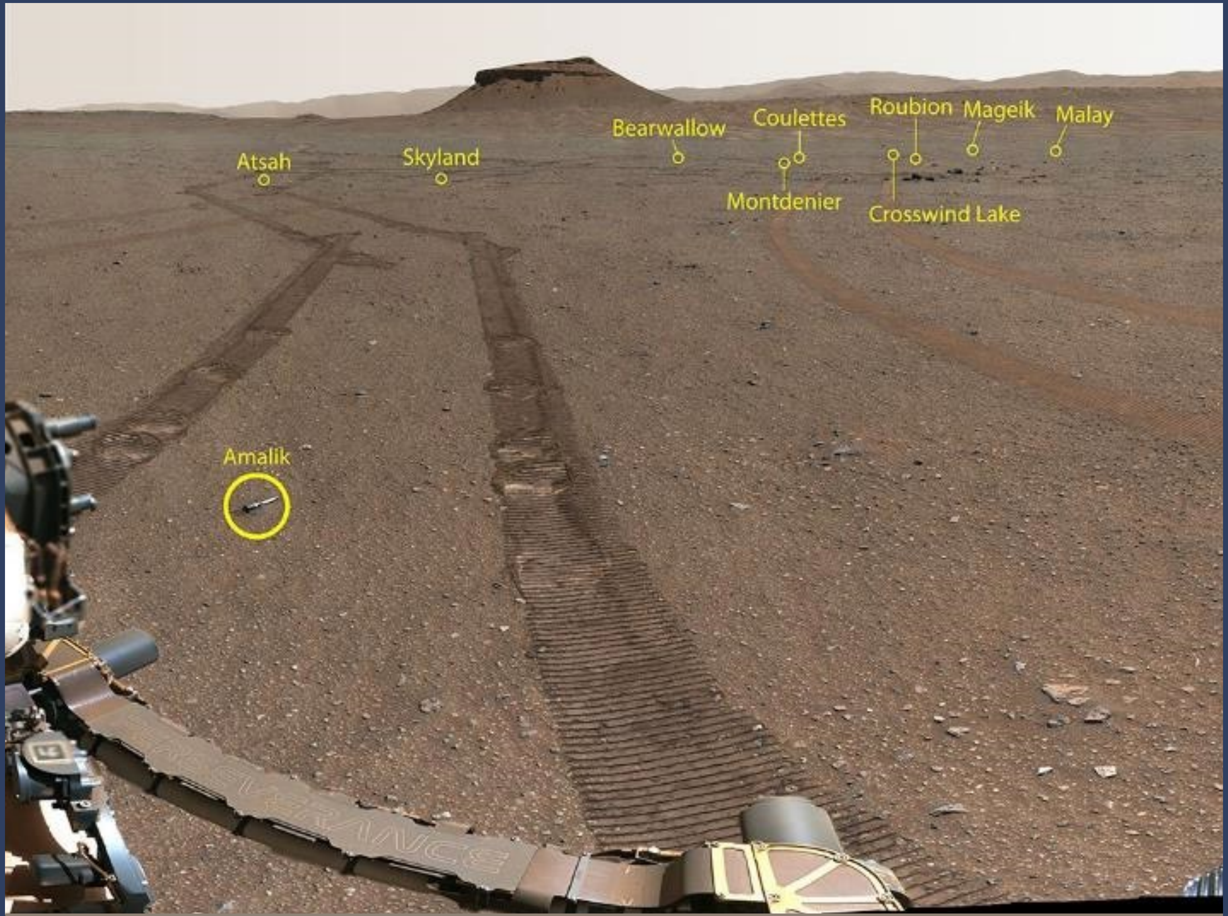
- Initial surface depot completed
- Science team has discontinued paired sampling and Perseverance plans to retain all remaining samples onboard
- Prime mission completed on Jan 6, 2023

Mars Draft Strategy: NASA internal stakeholder review underway

- Planning to present at MEPAG and next PAC to solicit community feedback later this spring

Mars Data Analysis Program (MDAP) proposals are mid-review

- Selection announcement planned for mid-April



NASA's Perseverance Mars rover captured this portrait of its recently completed sample depot using its Mastcam-Z camera on Jan. 31, 2023. This panorama is made up of 368 individual images that were stitched together after being returned to Earth. Credit: NASA/JPL-Caltech/ASU/MSSS

Mars Exploration Program Evolution

Key NASA Mars Priorities

- Executing Mars Sample Return is the highest planetary science priority
- Supporting ESA's Rosalind Franklin Mission
- Progressing MEP Science Objectives
- Maintaining critical infrastructure capabilities

NASA Orbiters well beyond original estimated lifetimes

- Mars Relay Network (MRN) activities managed closely to maintain asset communications
- MRO (2005) HiRISE provides critical Mars surface imaging

Business Landscape Changing

- Broadened international participation
- Expanding industry interest and capability
- Preparing for human presence at Mars (Moon2Mars)

HiRISE Assist to InSight

An impact crater, formed Dec. 24, 2021, by a meteoroid strike in the Amazonis Planitia region of Mars, was captured by HiRISE. Boulder-size blocks of water ice can be seen around the rim of the crater. Credit: NASA/JPL-Caltech/University of Arizona

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Preview of MEP Draft Strategy

2023-2044 Program Science Goals:

- Explore the Potential for Martian Life
- Discover Dynamic Mars (system science of geologic and climatological processes)
- Perform Complementary science supporting the human exploration of Mars

MEP Draft Strategy Focus:

- Achieve Decadal-class science (MSR, search for life)
- Refresh communication and imaging infrastructure at Mars
- Invest in technology priorities that map to science objectives (EDL, subsurface access, surface mobility)
- Utilize low-cost initiatives to meet science priorities (dependent on infrastructure and technology investments)
- Leverage collaborations – commercial and international partners (rideshare, comm, joint missions)
- Establish synergies with human exploration of Mars (prepare for, and science operations)
- Maintain Program of Record
- Enable Diverse community participation (opportunities to increase access to Mars)
- Inspire current and future generations to explore space

MEP International Interests

Potential Collaboration on ESA's Rosalind Franklin Mission

- ESA implementing a renewed ExoMars/Rosalind Franklin mission to launch in 2028; assumes NASA participation
- NASA participation subject to the availability of U.S. funding
- Contributions may include descent engines, radioisotope heater units, and launch service

ASI, CSA, and JAXA continuing activities for the International Mars Ice Mapper (IMIM) mission

- Discussions ongoing for a potential NASA contribution; may include a science payload, communication relay, and launch services

Mars Orbiters

Mars Relay Network (MRN)

- MEP successfully managing network activities with aging orbiters that are well into their extended missions
- MRN Health Assessment conducted in July 2022; Only 1 asset (ESA's TGO) expected to be viable into mid-2030; MEP Draft Strategy plan includes focus on refreshing comm relay capability

Odyssey

- Results of propellant investigation now estimates remaining propellant at 4 kg +/- 2 kg, usage 1 kg/year
- Project began its **9th extended mission** in October 2022

MAVEN

- Operating in all-stellar attitude sensing mode to preserve lifetime of remaining IMU
- Experienced safe mode event due to IMU this past February
- Achieved its 18,000th orbit in Jan 2023
- Project began its **5th extended mission** in October 2022

MRO

- No safe mode events since Nov 2022
- MRO experiencing approximately 3 safe mode events per year since 2020; no root cause, but events associated with Galactic Cosmic Radiation maxima
- Project began its **6th extended mission** in October 2022

ExoMars/TGO

- Continuing to support relay operations for MEP; returning >50% relay data of landed assets

Mars2020 Ingenuity

Completed 45 successful flights!

As of February 23, 2023

Survived a full Martian year of winter

- Sol 712 (Feb 19, 2023) marked 668 Sols since Ingenuity deployment from Perseverance on Mars

Currently advancing up Jezero delta ahead of Perseverance

- Performing scouting for Perseverance along path to Delta Top Campaign area - identify terrain inaccessible to rover and evaluate sampling targets for sample value
- Operations optimized for minimal interference to Perseverance – flights planned on opportunistic basis

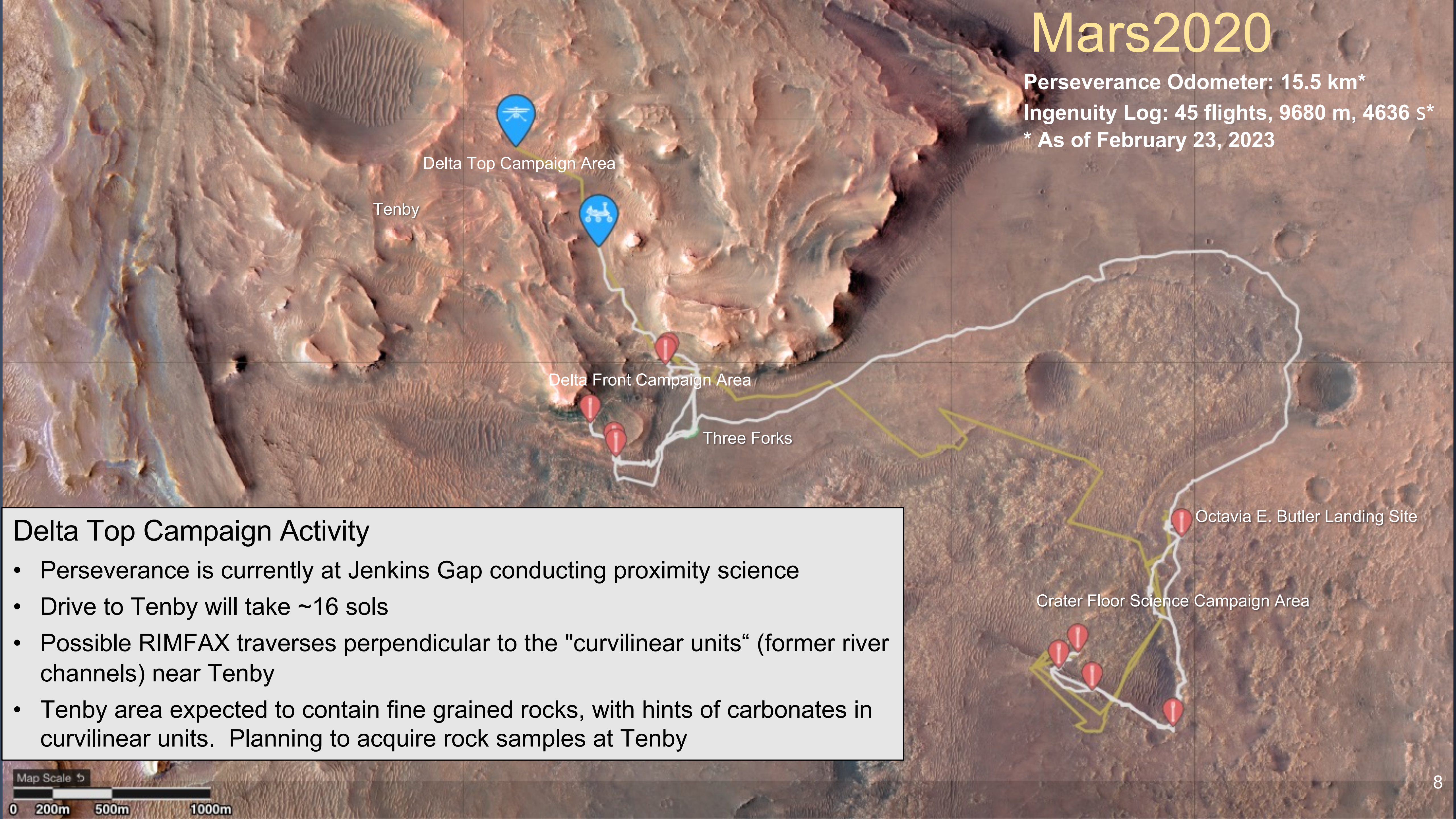
Hazard Avoidance Software Upgrade

- Successfully using new software since Flight 37 (Dec 17, 2022) to recognize and divert away from incompatible terrains during landing operations
- Risk Mitigation for MSR Sample Recovery Helicopters

NASA’s Ingenuity Mars helicopter is seen here in a close-up taken by Mastcam-Z, a pair of zoomable cameras aboard the Perseverance rover. This image was taken on April 5, the 45th Martian day, or sol, of the mission. Credits: NASA/JPL-Caltech/ASU.

Mars2020

Perseverance Odometer: 15.5 km*
Ingenuity Log: 45 flights, 9680 m, 4636 s*
*** As of February 23, 2023**

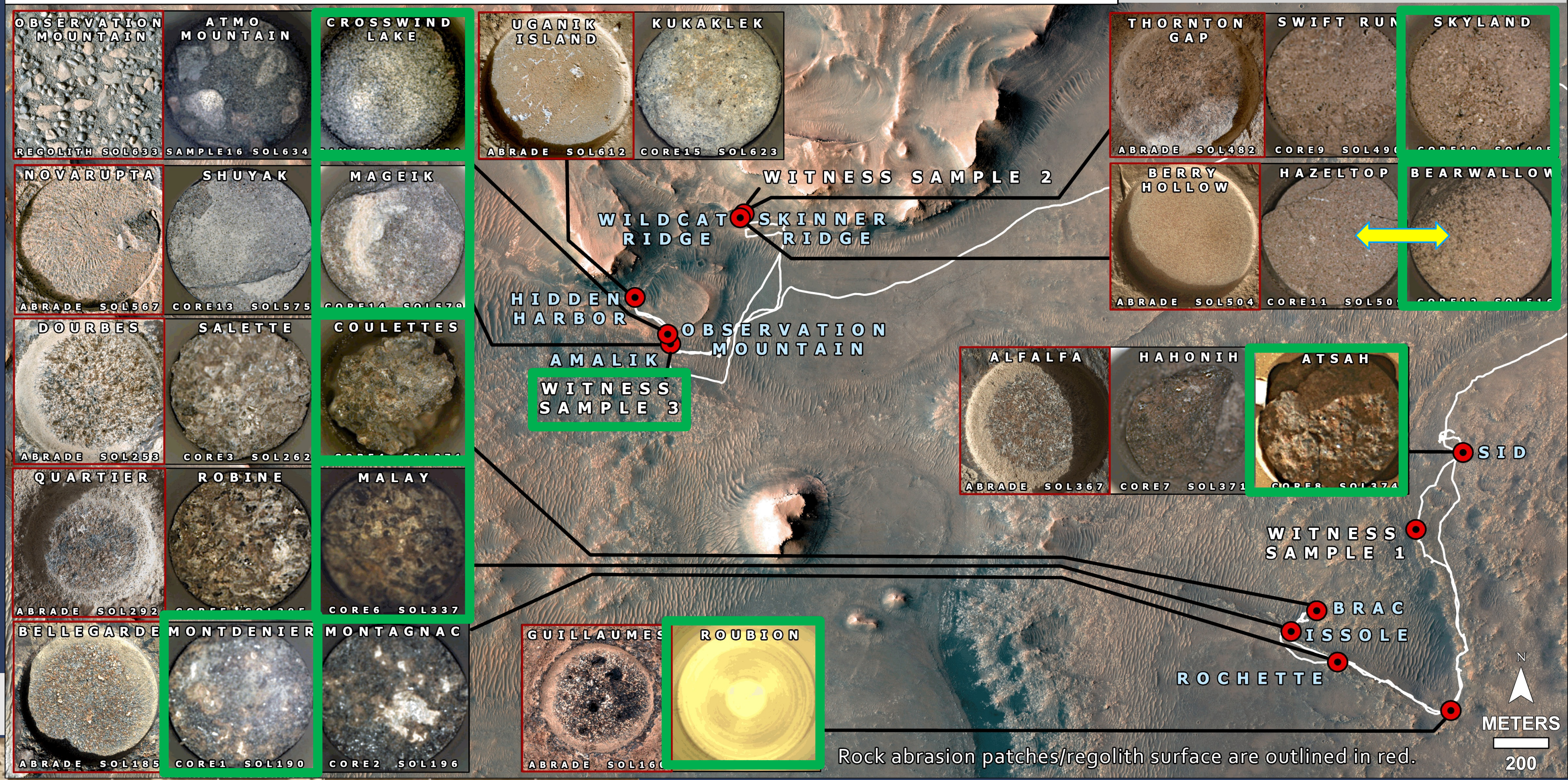


Delta Top Campaign Activity

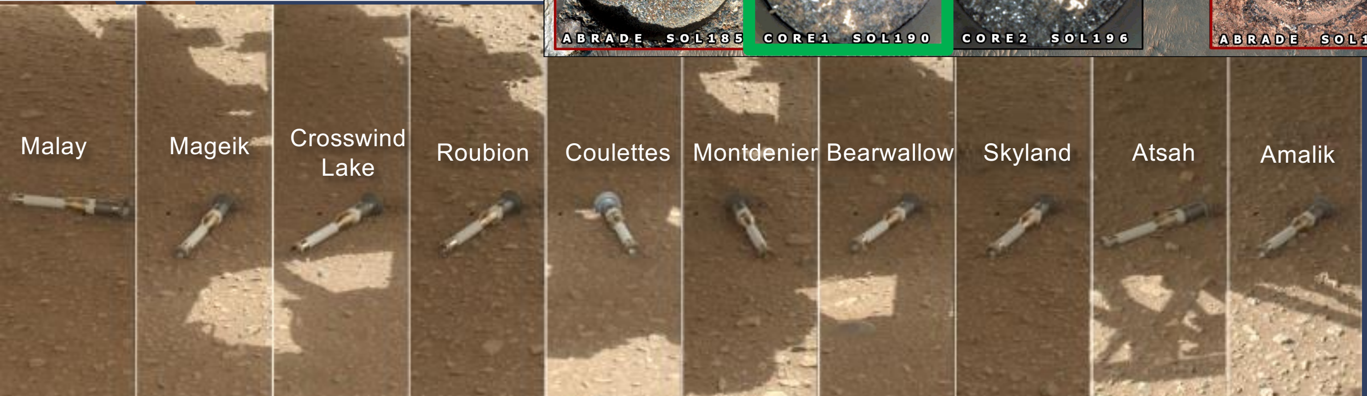
- Perseverance is currently at Jenkins Gap conducting proximity science
- Drive to Tenby will take ~16 sols
- Possible RIMFAX traverses perpendicular to the "curvilinear units“ (former river channels) near Tenby
- Tenby area expected to contain fine grained rocks, with hints of carbonates in curvilinear units. Planning to acquire rock samples at Tenby

Sample Collection Map: Tubes 1-21

Green indicates tubes cached at Three Forks



WATSON Photomontage of Three Forks Cache. Credits: NASA/JPL-Caltech/MSSS



Sample Receiving Project

Project formally established at JSC in Dec 2022
- Project Manager, Alvin Smith PhD, selected, starts mid-March

MSR is Planetary Protection Category V (restricted Earth return)
- Requires containment in Biosafety Level (BSL)-4 equivalent facility in preparation for safe release of the samples

Returned Sample Safety Assessment
- Program personnel working with scientific teams, policy, and Office of Planetary Protection to establish implementation of sample safety assessment framework that ensures safety and enables expeditious distribution to the scientific community

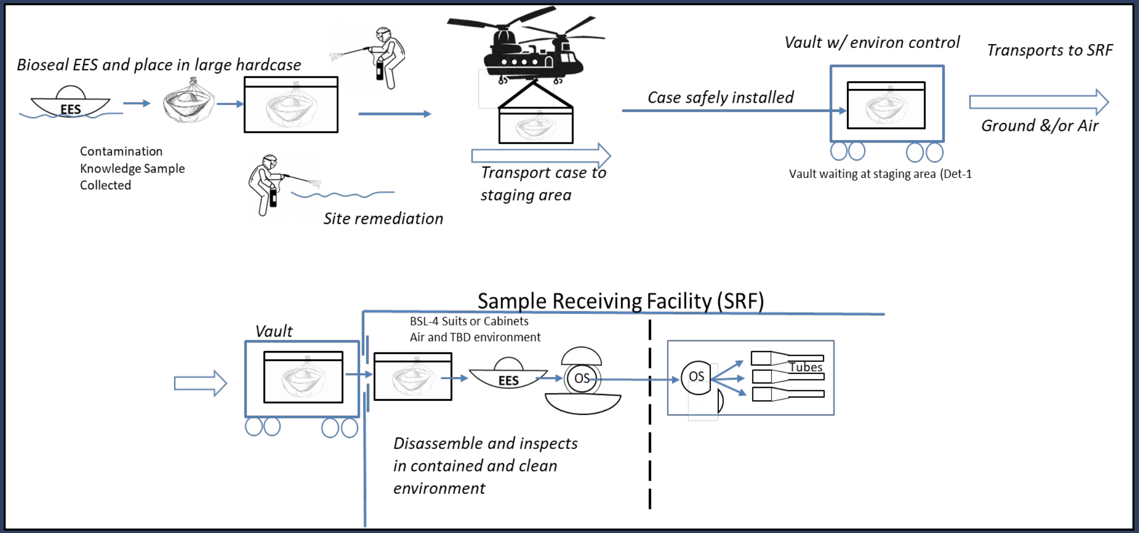
Sample receiving facility modality study
- Study out-brief presentations in March 2023

NEPA Environmental Impact Statement
- Refining work scope, commence late summer 2023

ESA Collaboration
- ESA science and curation personnel integrated with SRP team

The SRP is the final element of the MSR Campaign that has a defined mission to recover, contain, transport, assess safety of, curate and scientifically investigate the samples returned to Earth by the MSR Program

<u>Primary Goal: Enable safe and rapid release of the returned samples to world-wide labs for science investigations</u>



Mars Science Laboratory (MSL) Curiosity

Curiosity is exploring Marker Band Valley and continues to ascend Mt. Sharp

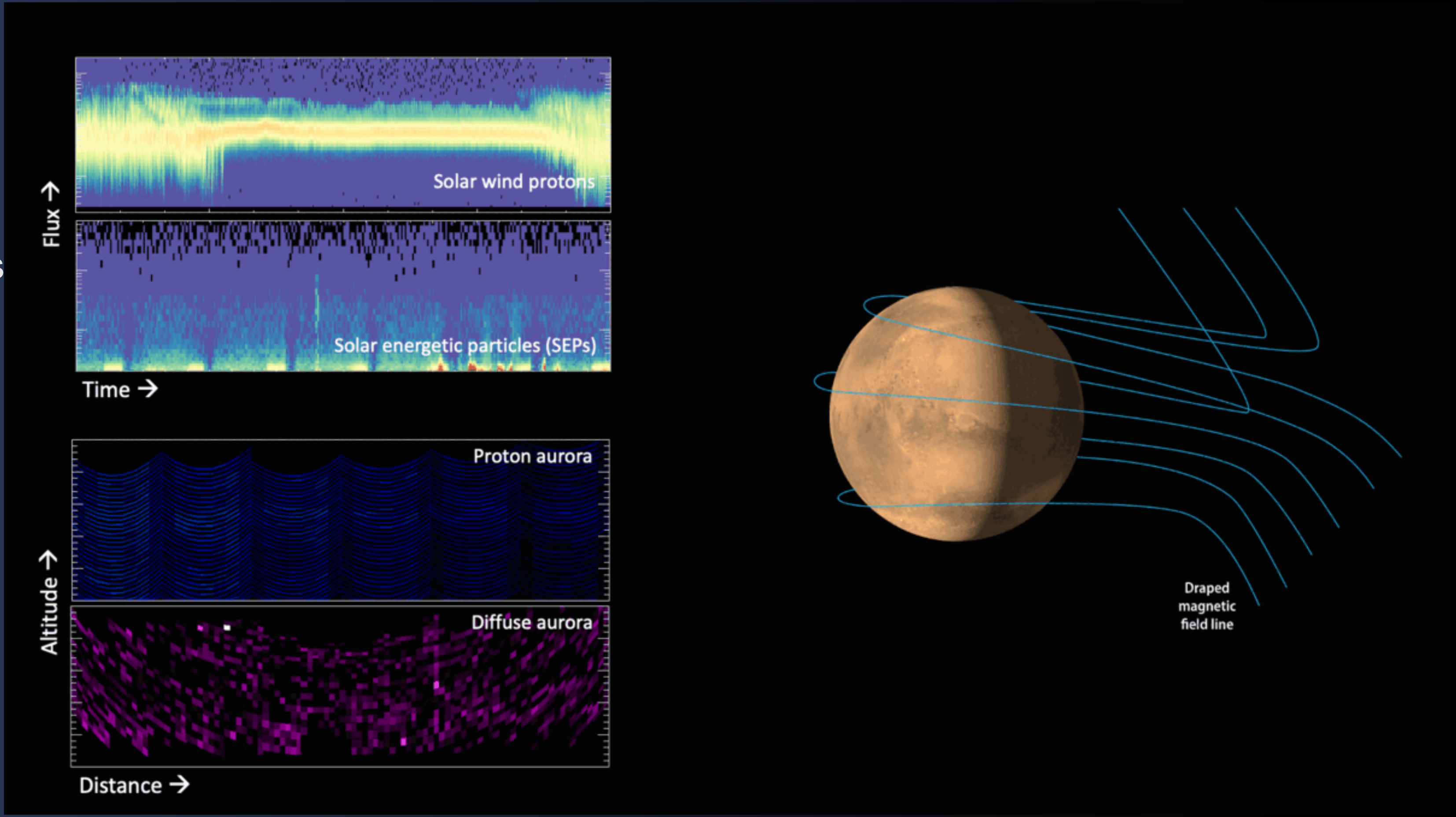
- Driven over 18.5 miles (30 kilometers) and gained over 2,000-foot (600 meters) of elevation
- All ten instruments are returning high-value scientific measurements
- Rocks within Marker Band have been very hard to drill, attempts at Encanto, Amapari, and Dinira sites
- Wave ripples very clear, surprising since this area likely formed at a time when Mars was getting drier
- Analyzed 42 rock and soil samples; 36 drill holes

Rippled Rock Textures: Billions of years ago, waves on the surface of a shallow lake stirred up sediment at the lake bottom. Over time, the sediment formed into rocks with rippled textures that are the clearest evidence of waves and water that NASA's Curiosity Mars rover has ever found.
Credits: NASA/JPL-Caltech/MSSS

Recent mission update video → https://youtu.be/NuoR4XMmJO0

MAVEN Observes Martian Light Show

- For the first time in its eight years orbiting Mars, NASA's MAVEN mission witnessed two different types of ultraviolet aurorae simultaneously
- On Aug. 27, 2022, an active region on the Sun produced a series of solar flares and a coronal mass ejection, resulting in one of the brightest solar energetic particle (SEP) events that the MAVEN spacecraft has ever observed
- The energetic particles unleashed by this solar storm bombarded Mars' atmosphere, causing bright auroras at ultraviolet wavelengths. MAVEN's Imaging Ultraviolet Spectrograph (IUVS) instrument observed two types: diffuse aurora and proton aurora.
- MAVEN is the only asset at Mars able to observe the Sun's activity and the response of the thin Martian atmosphere at the same time



https://www.nasa.gov/feature/goddard/2022/nasa-s-maven-observes-martian-light-show-caused-by-major-solar-storm

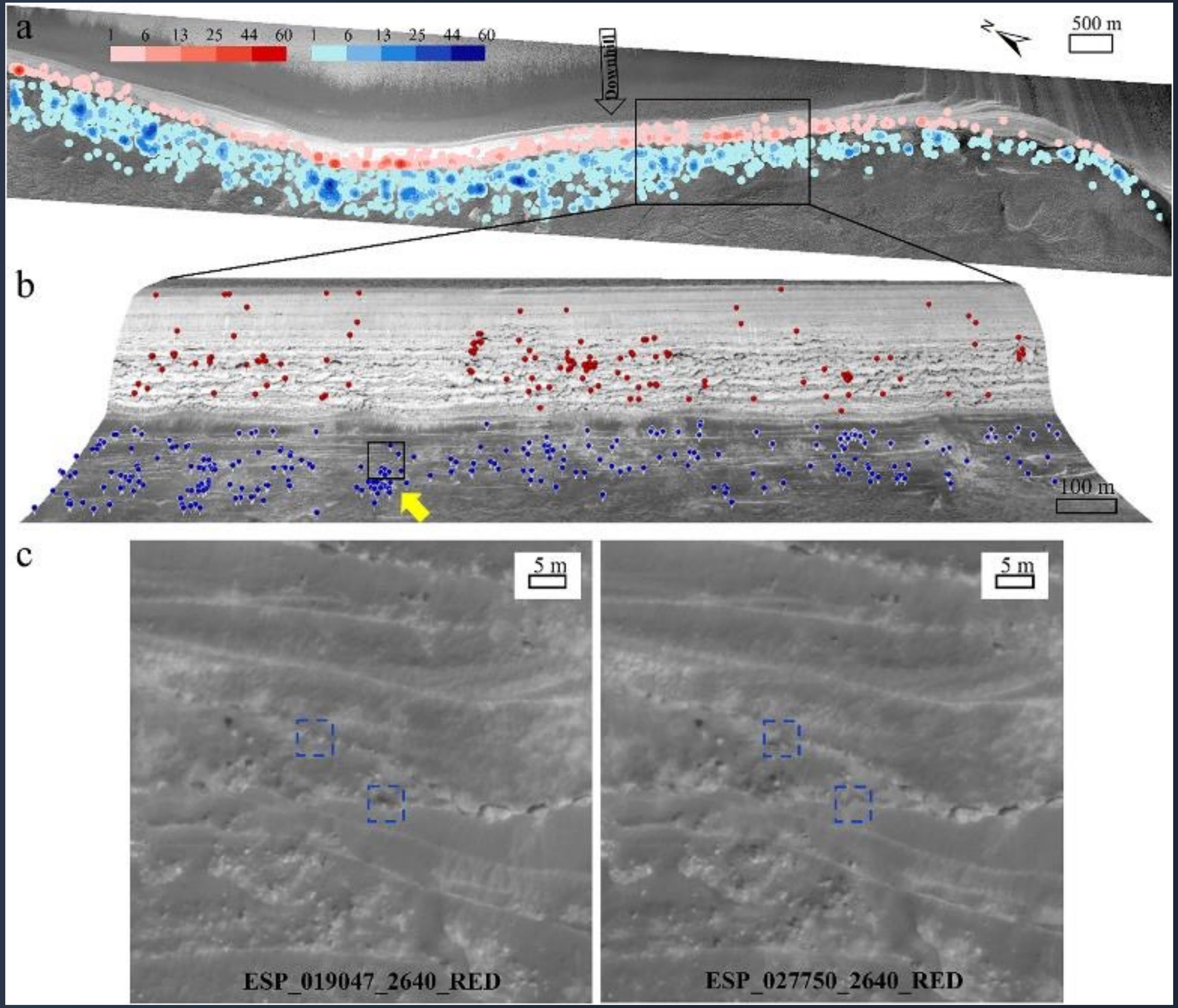
MRO Science Highlight

Searching for the sources of ice block falls at the Martian north polar scarps

S.Su, L.Fanara, X.Zhang, E. Hauber, K. Gwinner, J.Oberst

Icarus, Volume 390, 15 January 2023, 115321
https://doi.org/10.1016/j.icarus.2022.115321

- Automated counts performed on MRO HiRISE data detected changes on steep polar cliffs where avalanches and blockfalls are active
- In top & middle images, density maps are shown of ice blocks (blue) at the base of cliffs and of their estimated origins (red) on the polar cap cliff edge. Bottom image shows example sources of ice block fall on cliff face. (Fanara et al., 2023, Fig. 9)
- ~129 block falls are occurring per Mars year per km^2 along the scarp on average, but there is some interannual variability. Such block falls were nearly absent in Mars Year (MY) 36
- An ongoing MRO HiRISE investigation in the current MY37 will test whether the pause in MY36 was temporary or whether rates will return to the longer-term average



Data CREDIT: MRO HiRISE / U. Arizona / JPL / NASA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Mars Sample Return Campaign Overview

Mars Sample Return Program

1

Mars 2020 Sample Caching

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

2

Sample Retrieval Lander (SRL)

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

3

Earth Return Orbiter (ERO)

- *Capture and contain samples in Mars orbit*
- *Safely return samples to Earth for recovery at landing site*

4

Sample Receiving Project

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

- The MSR Campaign spans 2 programs, multiple launches, and an Earth element
- The Mars Exploration Program manages M2020 operations & the Sample Receiving Project (SRP)
- The MSR Program manages development and operations of the SRL and ERO

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Summary of Mars Relay Network (MRN) Assets

Mission	Agency	Launch Year	Orbit	UHF Relay Payload	Max Return-Link Data Rate
ODY 	NASA	2001	385 km x 450 km 93 deg incl	CE-505 redundant units, quadrifilar helix antenna, 12 W transmit power	256 kb/s
MEX 	ESA	2003	298 km x 10,100 km 86 deg incl	Melacom single unit, patch antennas, 8.5 W transmit power	128 kb/s
MRO 	NASA	2005	255 km x 320 km 93 deg incl	Electra redundant units, quadrifilar helix antenna, 5 W transmit power	2048 kb/s adaptive data rate enabled
MAVEN 	NASA	2013	~200 km x 4500 km 75 deg incl	Electra single unit, quadrifilar helix antenna, 5 W transmit power	2048 kb/s adaptive data rate enabled
TGO 	ESA	2016	400 km x 400 km 74 deg incl	Electra redundant units, quadrifilar helix antenna, 5 W transmit power	2048 kb/s adaptive data rate enabled

Status of Aging Mars Relay Network Assets

Mission	Mission Status
ODY 	Fuel usage is ~1 kg/yr, with ~4kg remaining. “All-stellar mode” in use to preserve IMU lifetime. No remaining redundancy in reaction wheel assembly; loss of another wheel would reduce remaining mission lifetime to ~1yr.
MEX 	Fuel load extremely low and uncertain. “All-stellar” mode in use to preserve IMU lifetime. Available for emergency relay services for NASA’s landed assets.
MRO 	Fuel usage ~10 kg/yr, with ~150 kg remaining. “All-stellar mode” in use to preserve IMU lifetime. X-band TWTA is effectively single-string due to waveguide transfer switch (WTS) anomaly.
MAVEN 	Fuel usage ~5 kg/yr, with ~70 kg remaining. Fuel usage planned to allow science and relay operations through 2031. “All-stellar” mode in use to preserve limited lifetime on single remaining degrading IMU.
TGO 	Fuel usage is ~8 kg/yr, with >200 kg remaining. All subsystems nominal with full redundancy available. Lifetime extension methods (e.g., “all-stellar” mode) under study. Presently returning >50% of relay data from NASA’s landed assets.