National Aeronautics and Space Administration

EXPLORE

MARS SAMPLE RETURN

Committee on Astrobiology and Planetary Sciences

September 29, 2022

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The decision to implement Mars Sample Return will not be finalized until NASA's completion of the National Environmental Policy Act (NEPA) process. This presentation is being made available for information purposes only.

GOAL —
First Sample Return From Another Planet

A priority since 1980 and of three National Academy Decadal Surveys
A first-step “round-trip” in advance of humans to Mars

The oldest known life on Earth existed ~3.5 billion years ago,
a time when Mars was habitable. Today,
<1% of Earth’s surface is 3 billion years or older
>50% of Mars’ surface is 3 billion years or older

The first billion years and life’s beginning in the Solar System:
A More Complete Record Likely on Mars

THE WHY? What Makes MSR so Valuable?

Four powerful technical advantages:

Access to sophisticated sample preparation

Organic prep. pathways

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

Multiple, diverse, and large instruments that cannot be miniaturized

- *Opportunity to make confirming measurements using multiple methods*
- *"Gift that keeps on giving" – analysis by future instruments*
- *"Extraordinary claims require extraordinary evidence"*

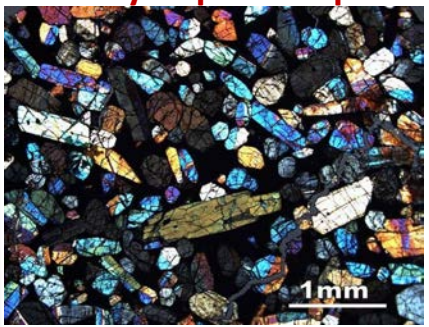
SEM

Discovery-responsive investigation pathways

- *Answers to early questions change choice/design of later experiments*

Thin section

Greatly improves spatial

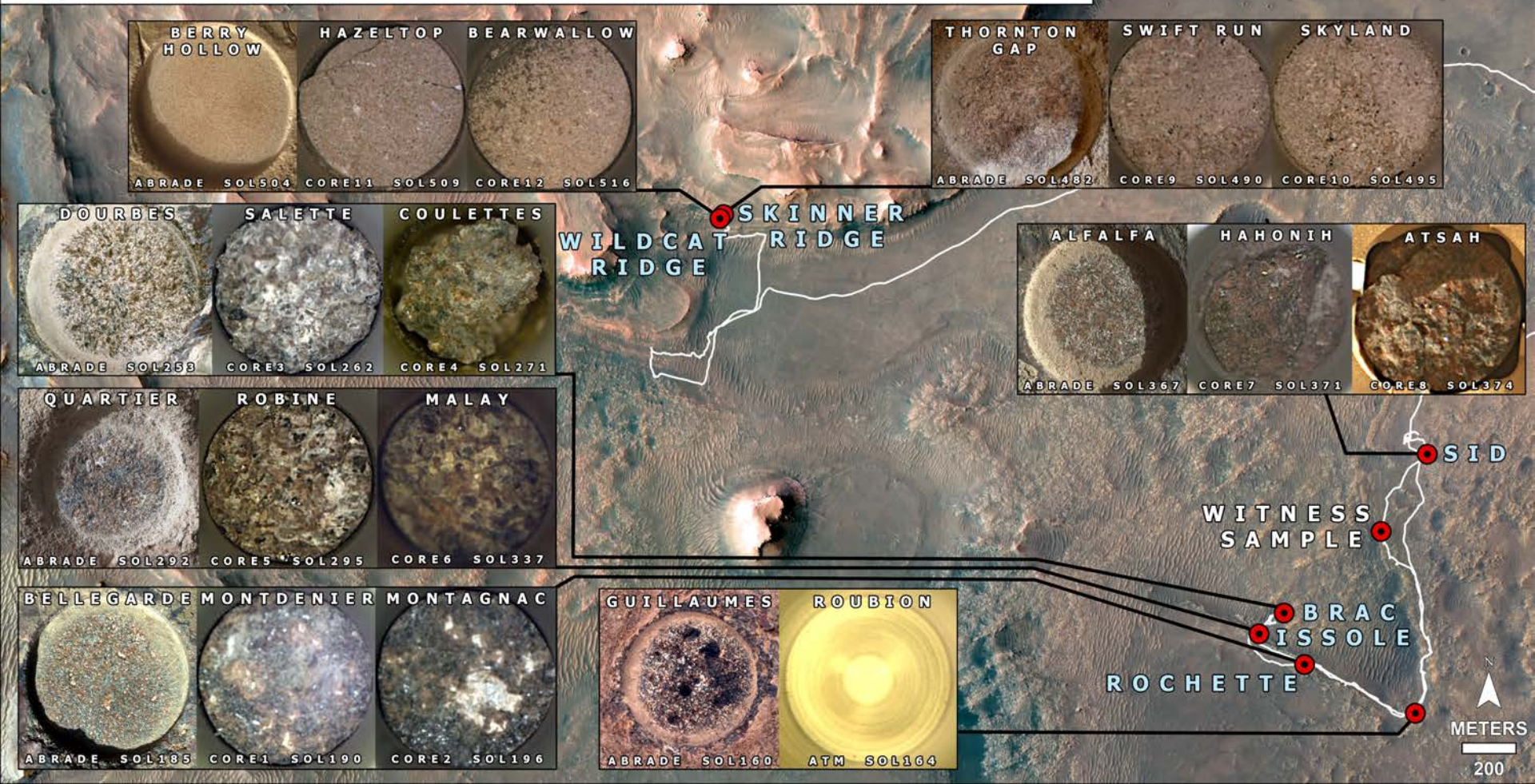


- *For evaluating microbial life, microscopic scale is crucial*
- *Access to small grains crucial*

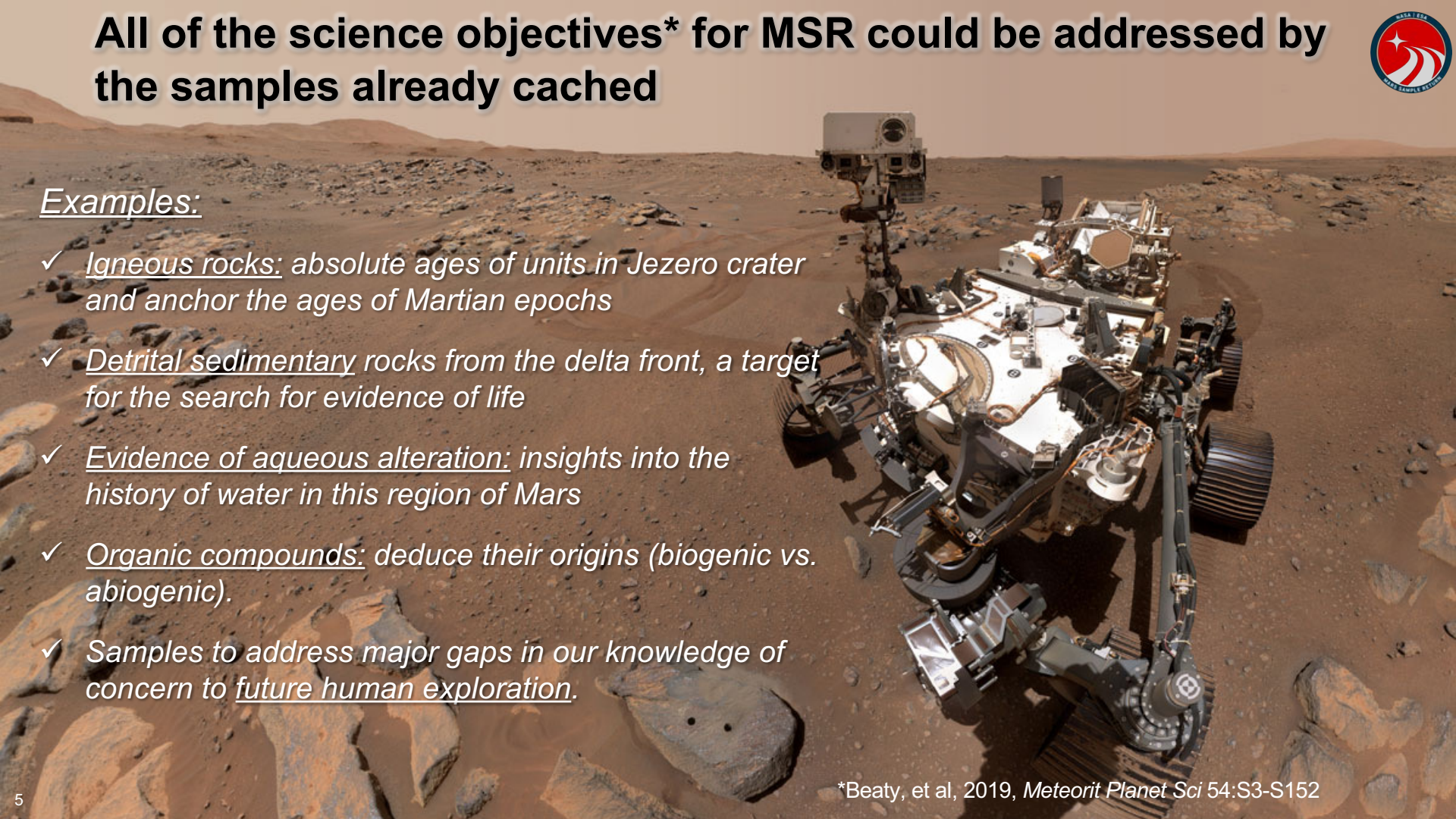
Mars meteorite

MARS 2020 PERSEVERANCE Sample Collection Map: Cores 1-12

+ Two Witness Tubes & One Atmosphere Sample



All of the science objectives* for MSR could be addressed by the samples already cached



Examples:

- ✓ *Igneous rocks: absolute ages of units in Jezero crater and anchor the ages of Martian epochs*
- ✓ *Detrital sedimentary rocks from the delta front, a target for the search for evidence of life*
- ✓ *Evidence of aqueous alteration: insights into the history of water in this region of Mars*
- ✓ *Organic compounds: deduce their origins (biogenic vs. abiogenic).*
- ✓ *Samples to address major gaps in our knowledge of concern to future human exploration.*

*Beaty, et al, 2019, *Meteorit Planet Sci* 54:S3-S152

Mars Sample Return mission architecture has been refined and is designed to safely bring scientifically selected samples to Earth for study using the most advanced laboratory instruments—those that will exist in the coming decade and those in the decades that follow.

- The campaign is designed around the ability to go where the science takes us, to facilitate bringing back the most valuable samples
- The architecture is complex and optimized to reduce development risk while ensuring scientific integrity of the samples

"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 (April 2022)

MSR Campaign & Program

- The MSR Campaign spans multiple launches and one ground element.
- The MSR Program manages development and operations of elements 2 and 3 and interfaces to elements 1 and 4.
- MSR Program concludes after recovery/containment of samples and transfer to a sample receiving facility.
- The Mars Exploration Program manages M2020 Phase E operations & the Sample Receiving Project (SRP) and would assume lead responsibility for recovery & containment of samples upon Earth landing.

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)

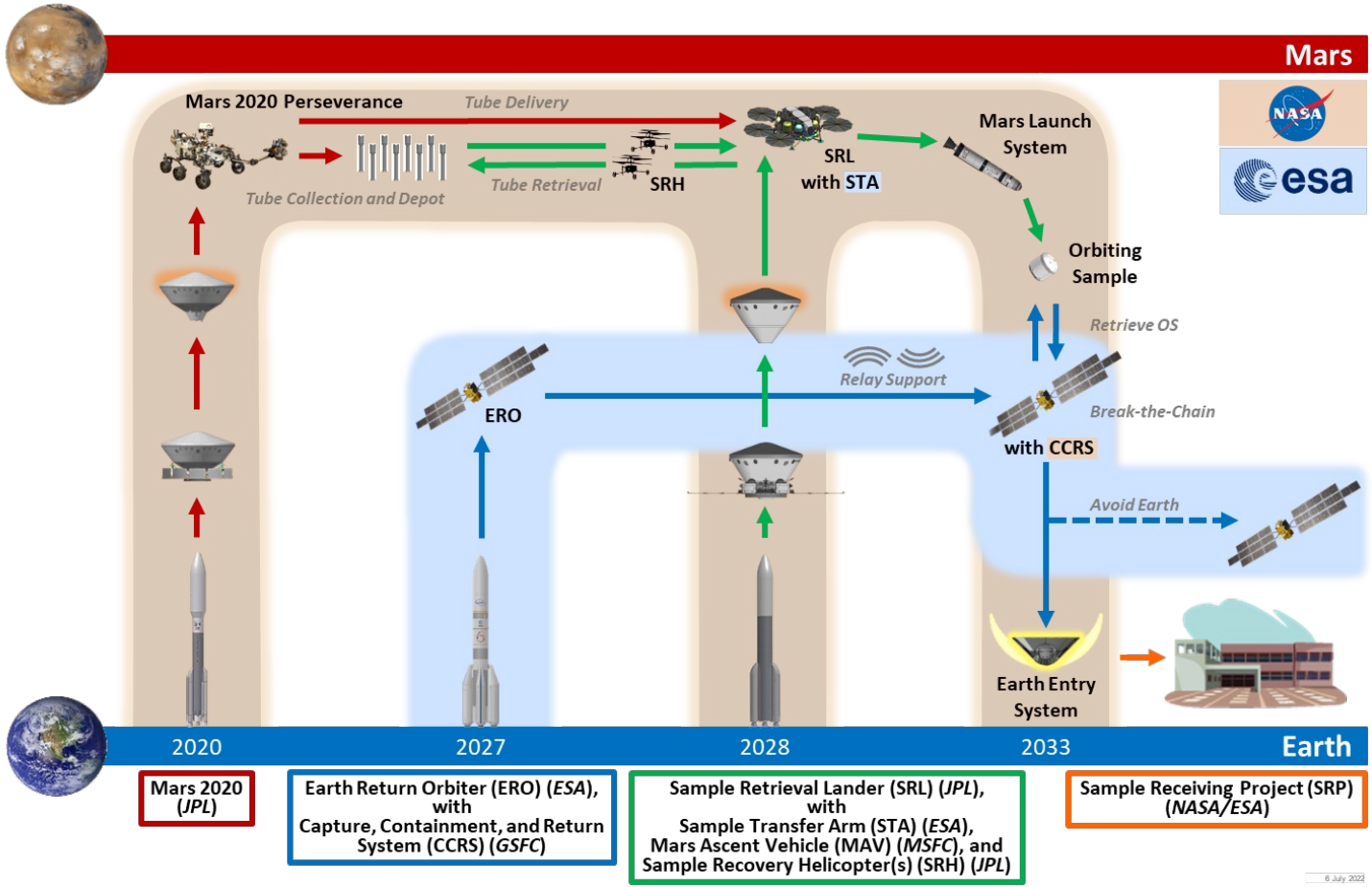
- *Capture and contain samples in Mars orbit*
- *Safely return samples to Earth for recovery at landing site*

4

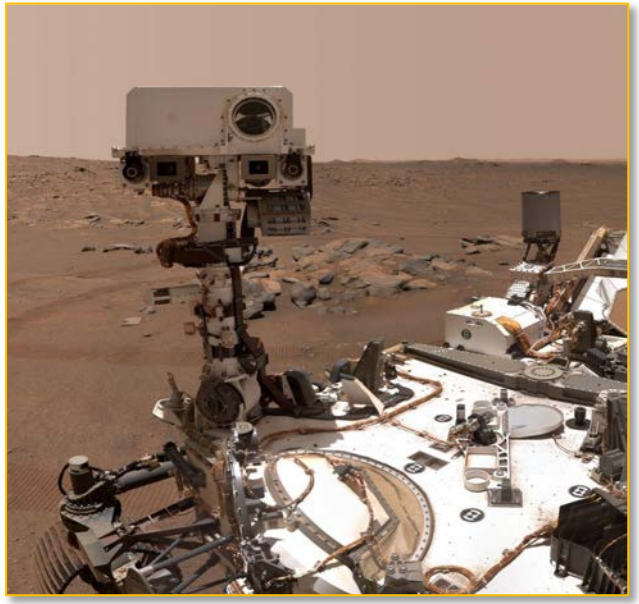
Sample Receiving Project

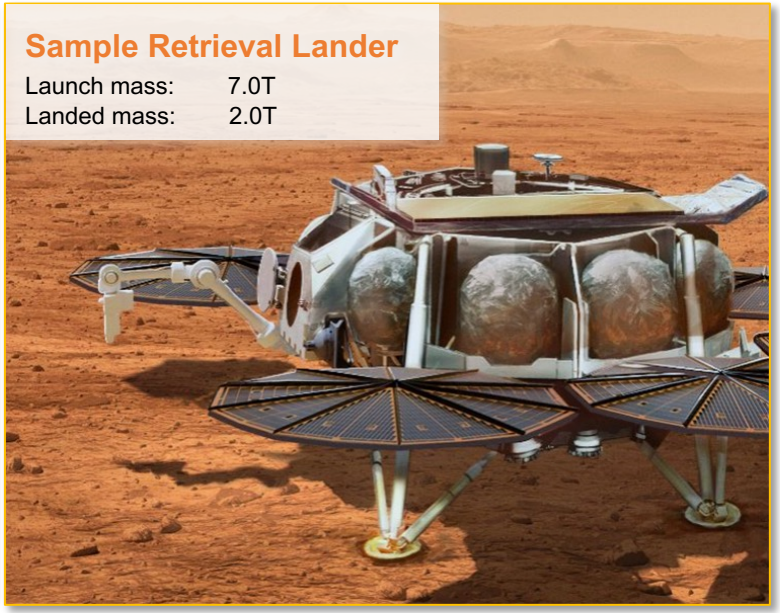
- *Recover and transport contained samples to receiving facility*
- *Safety assessment and sample containment*
- *Initial sample science and curation*

Program Architecture



NASA's Sample Retrieval Lander (SRL) with the Mars Ascent Vehicle (MAV), two Sample Recovery Helicopters (SRH), and ESA's Sample Transfer Arm (STA) would join the Perseverance rover near Jezero Crater.

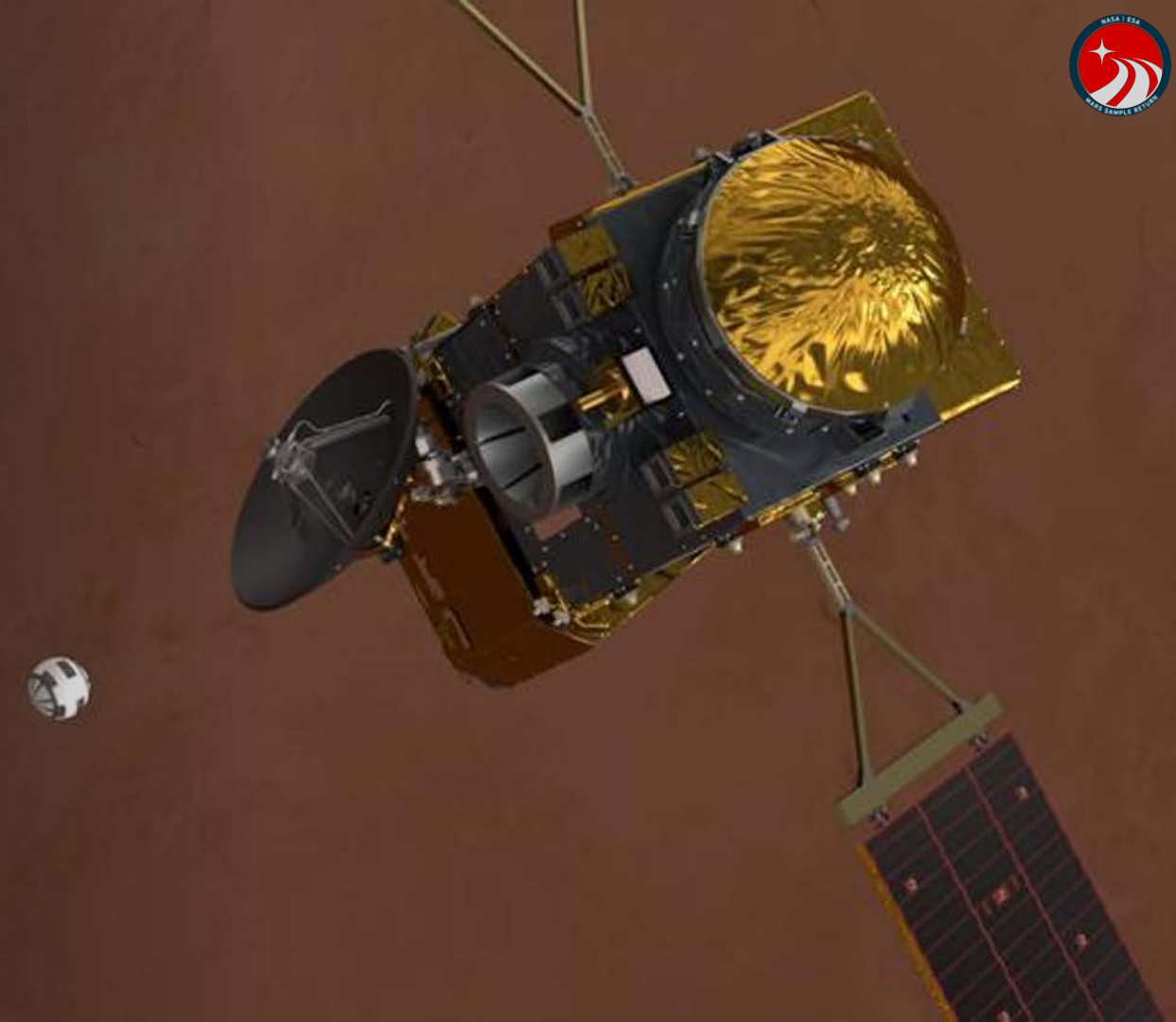




Mars Launch System / Mars Ascent Vehicle (MLS/MAV)

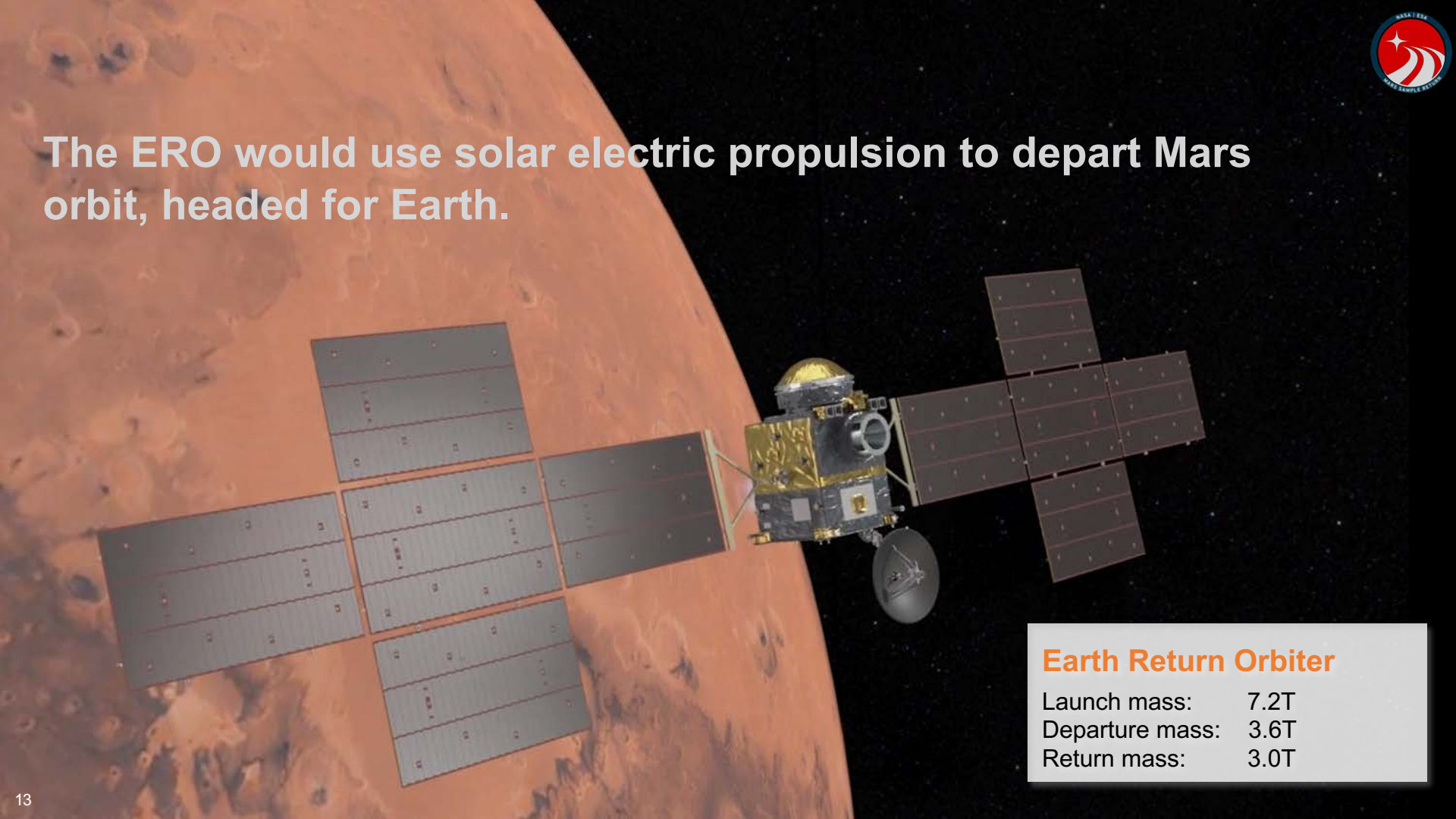
With samples in hand, the MAV would launch from the surface and place the Orbiting Sample container into orbit.

Another spacecraft, the ESA Earth Return Orbiter (ERO) would carry the Capture, Containment, and Return System (CCRS) to Mars. Once in orbit, it would provide data relay services during lander descent and surface phase operations through MAV launch, while waiting to collect the samples and return them safely to Earth.



The NASA-provided CCRS inside the orbiter would contain the sealed samples and prepare them for the return to Earth inside the Earth Entry System.

The ERO would use solar electric propulsion to depart Mars orbit, headed for Earth.

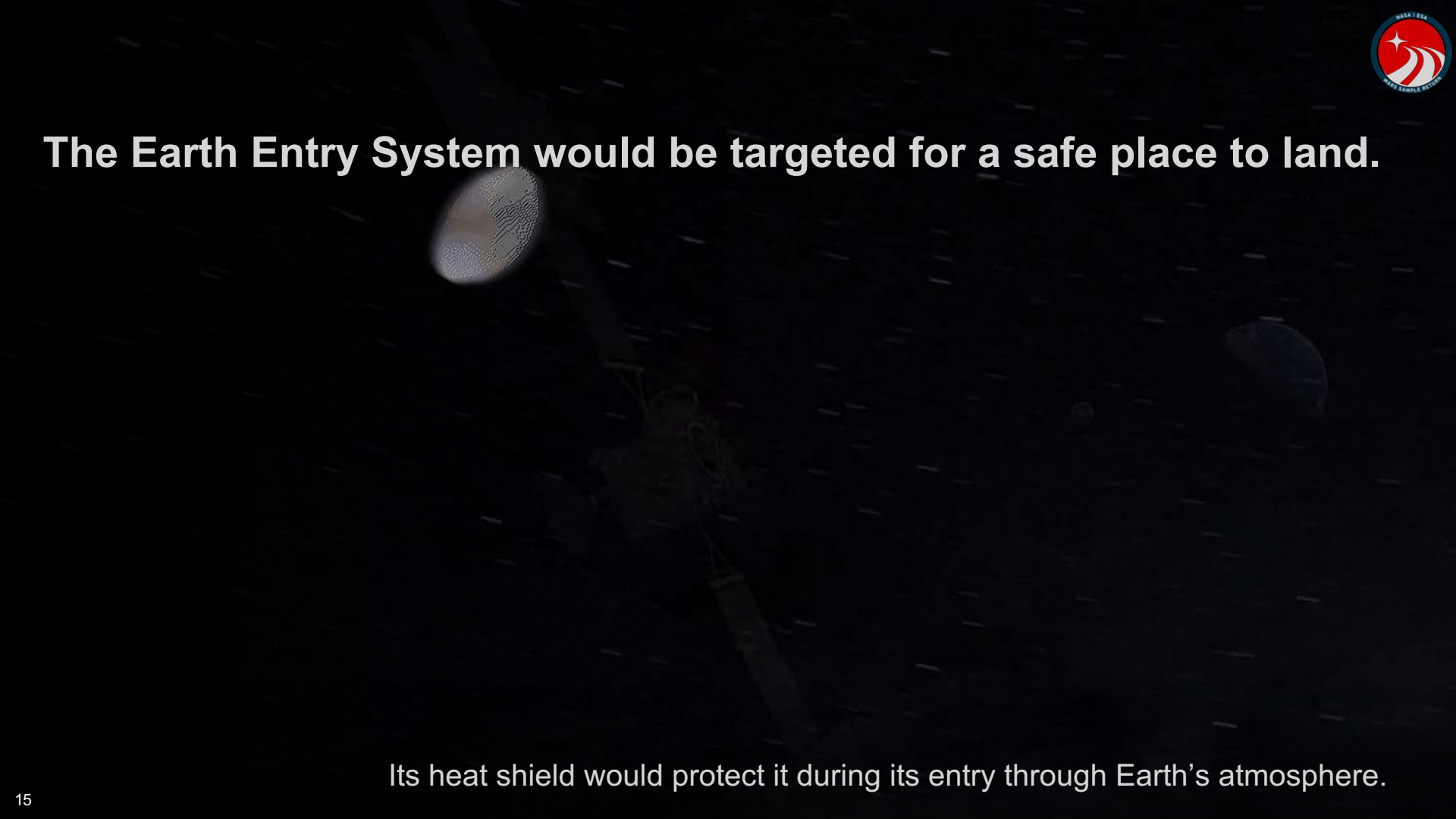


Earth Return Orbiter

Launch mass:	7.2T
Departure mass:	3.6T
Return mass:	3.0T

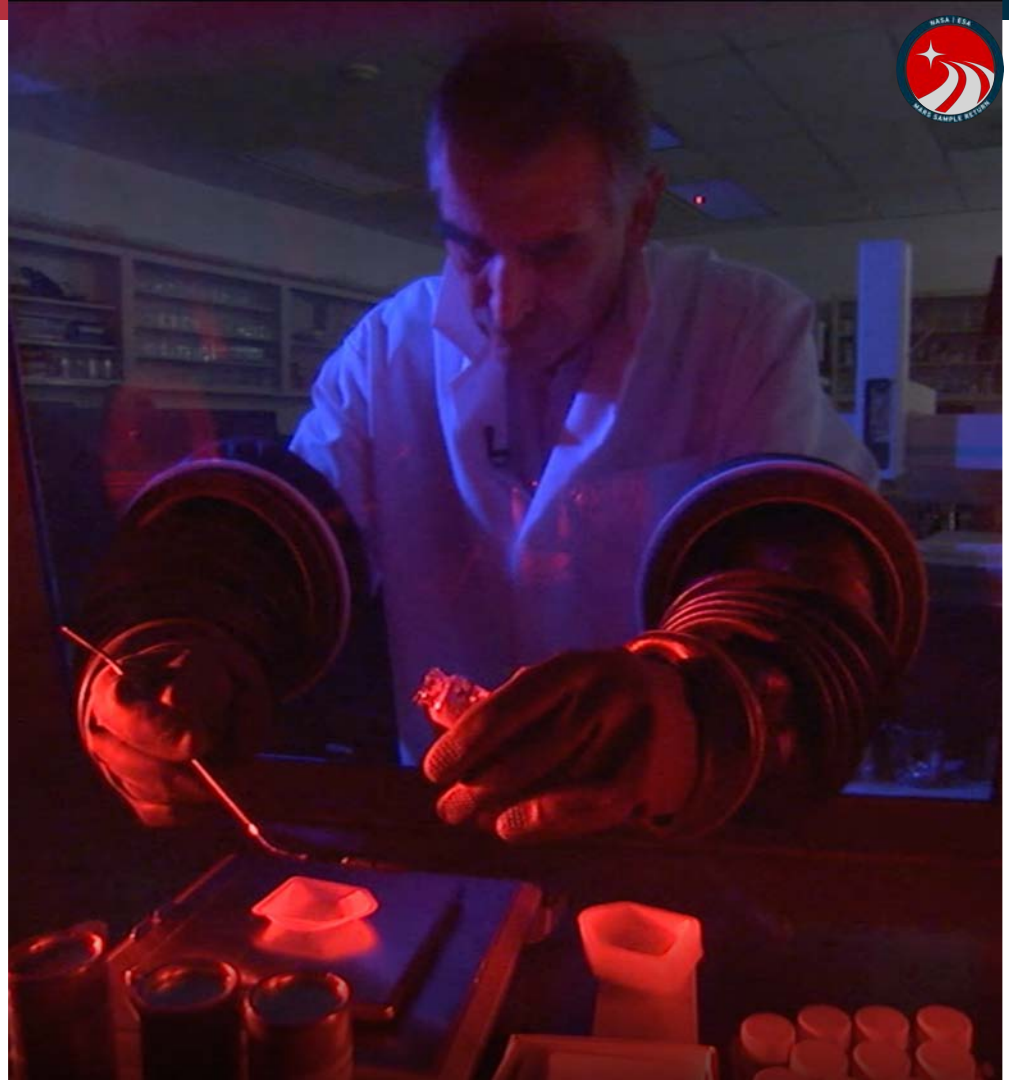
When flying past Earth, the ERO would release the Earth Entry System.

The Earth Entry System would be targeted for a safe place to land.



Its heat shield would protect it during its entry through Earth’s atmosphere.

On Earth, we can apply the full breadth of terrestrial science laboratories to study samples, including many instruments too large and complex to send to Mars, and including instruments yet to be invented.



The architecture was externally reviewed by an independent ESA-NASA Review Board at the Mission Definition Review (July 12-15, 2022)

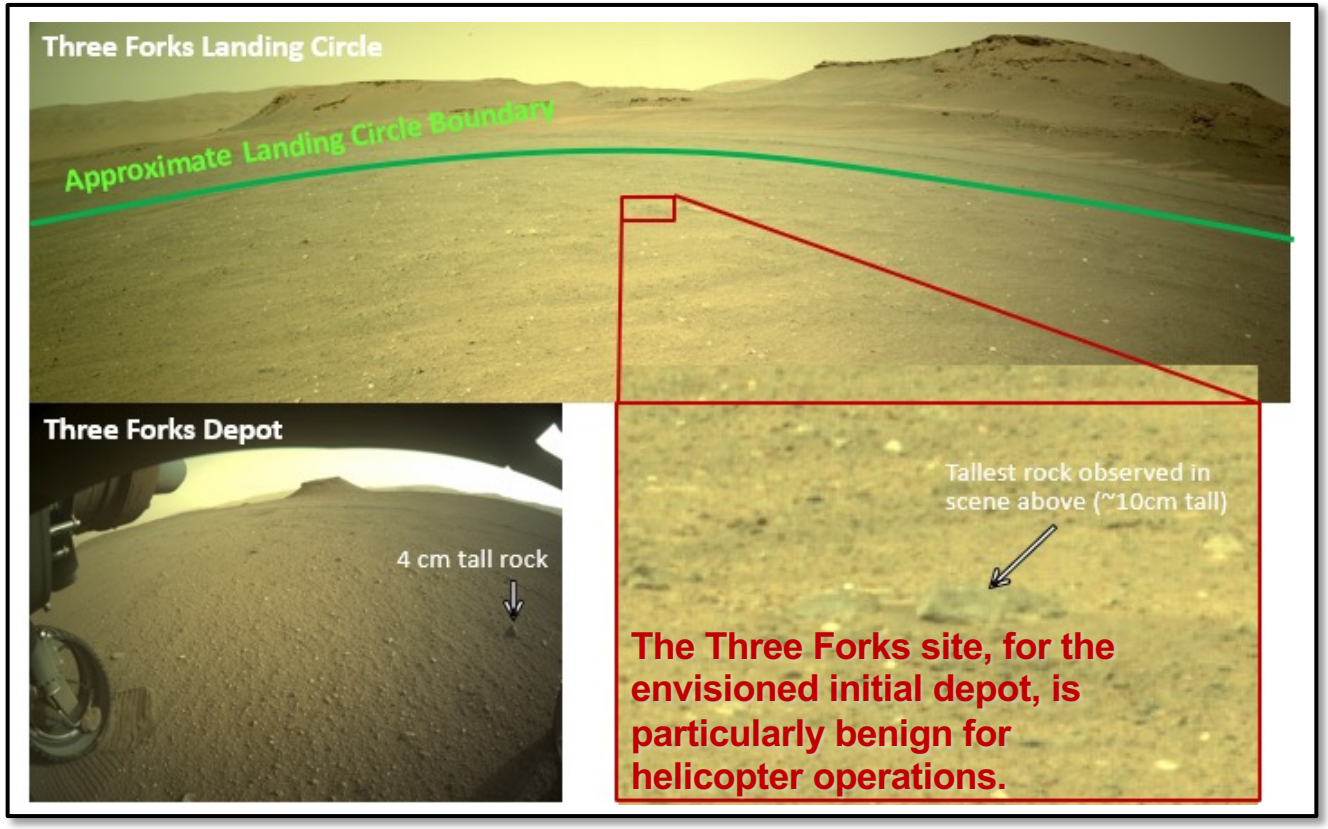
Entry into Phase B expected by end of September 2022

Planning is underway to establish an initial surface sample depot at Three Forks

Establishment of the initial depot will be preceded by a Science Team workshop to review caching plans.

The open **Mars 2020/MSR Sample Depot Science Community Workshop** will solicit input from the science community on the potential for the samples in this proposed depot to meet MSR's science objectives.

With a depot of scientifically exciting samples on the surface of Mars and another cached on the rover, two pathways to get samples to the lander exist.



Strategy for Initial Surface Depot

- **Working with the Mars 2020 Project to plan for initial surface depot**
  - Work in progress to certify the “Three Forks” area in Jezero Crater as the location for an initial cache depot and potential Sample Retrieval Lander landing site
  - Science and operations teams are preparing to deposit one set of the collected sample core pairs at Three Forks as early as November
- The initial depot is intended to be a risk mitigation against possible Perseverance catastrophic failure or major degradation (e.g., loss of mobility, loss of ability to drop tubes).
- Initial cache must be scientifically return-worthy (SRW)
  - Science community workshop scheduled for September 28th & 30th to help establish what constitutes a scientifically return-worthy sample cache
  - Anticipated to be 10-11 sample tubes containing core samples, regolith, atmosphere, witness tube(s)
  - From each core sample pair, one sample will be placed in the initial depot, and the other sample will be retained onboard Perseverance
- After placement of the initial depot, Perseverance will discontinue paired sampling and retain all acquired samples onboard until delivery to the Sample Retrieval Lander (SRL)
- In the event of a degradation in Perseverance’s state of health that threatens the ability to directly deliver samples to SRL, establishment of a second surface depot would be considered

Sample Recovery Helicopter (SRH)

Draft Top Level Requirements:

- Accommodate two helicopters on SRL
- Threshold use case is recovery of first depot (up to 12 samples) from Three Forks (single helicopter, with margin)
- Baseline use case: recover up to 30 samples (second depot) from site similar to Three Forks (requires both helicopters)

Proposed Approach

- Maximize Ingenuity rotor/airframe heritage
  - Demonstrated flight capability with sufficient margin to incorporate sample fetching, providing a viable back-up if Perseverance is disabled
- Add capability for sample recovery/transport to SRL

Key Challenges

- Mass
  - Testing planned for Fall ‘22 to validate flight envelope changes
- New capabilities (mobility, gripper)
- Schedule
  - Mission Concept Review conducted, June ‘22
  - System Requirements Review / Implementation Review Fall ’22

A Joint ESA-NASA MSR Campaign Science Group (MCSG) has been established and a Science MOU is in development

Phase 1 Participants

Co-Chairs


Michael Meyer


Gerhard Kminek

Joint Science Office


Dave Beaty


Elliot Sefton-Nash


Brandi Carrier


Fiona Thiessen


Tim Haltigin

Selected Members


Audrey Bouvier


Andy Czaja


Nicholas Dauphas

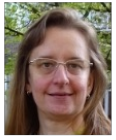

Kate French


Lydia Hallis


Rachel Harris


Ernst Hauber


Laura Rodriguez


Susanne Schwenzer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Michael Thorpe


Tomo Usui


Jessica Vanhomwegen


Michael Velbel


Maria-Paz Zorzano

Ex Officio


Sam Edwin


Ken Farley


Danny Glavin


Andi Harrington


Lindsay Hays


Aurore Hutzler


Mini Wadhwa

The **MSR Campaign Science Group** will be implemented in two phases as the Campaign transitions from ensuring sample integrity to planning and guiding the investigations of the samples

- Openly competed and jointly selected.
- Phase 1: Focus on Campaign science and sample integrity planning, developing ground-based infrastructure, and science community engagement
- Phase 2: Focus on the implementation of the objective-driven science

The **NASA-ESA Science Memorandum of Understanding (MOU)** is an agreement between agencies codifying our intended science collaboration. Anticipate agency agreement prior to ESA ministerial Nov. 2022

Mars 2020 / MSR Sample Depot Science Community Workshop

MCSG is organizing the Mars 2020 / MSR Sample Depot Science Community Workshop

- To be held over a two-day, non-consecutive period September 28 & 30
  - NASA/ESA science meeting separately on September 29th
- Pre-workshop information sent out September 21
- Focus topics:
  - Definition of "Scientifically Return Worthy" to aid in assessing samples to be deposited
  - Traceability Matrix of samples' potential to meet science objectives
  - Number of witness tubes to be included with the first deposit
- Final report expected mid-October

Looking Forward

- The joint NASA / ESA team is committed to returning the first scientifically selected samples from the surface of another planet

- Key Program Focus Areas
  - First-of-a kind technical developments (MAV, CCRS on-orbit assembly, OS rendezvous, SRH, EDL/pinpoint landing)
  - Schedule execution (staffing, supply chain, funding profile)
  - Planetary Protection
  - Coordination of complex multi-program partnership

- Near-term events
  - Key Decision Point-B Agency Program Management Council, 9/30
  - ESA Ministerial Mtg, 11/22-23
  - ERO Mission PDR, Jan-Feb 2023