Why Mars Sample Return?

Returning a carefully selected set of samples from Mars to Earth has been a major long-term goal of international planetary exploration for decades.

Data from past missions to the Red Planet have confirmed that areas of Mars offered habitable conditions that were capable of supporting life in the past. Evidence indicates that much of this warmer, wetter period is ancient, occurring about three billion years ago, during the same geologic age that early life was blooming on Earth. This commonality raises the prospect that discoveries on Mars can give us important insights about the origin and evolution of life on Earth.

The Path to Readiness

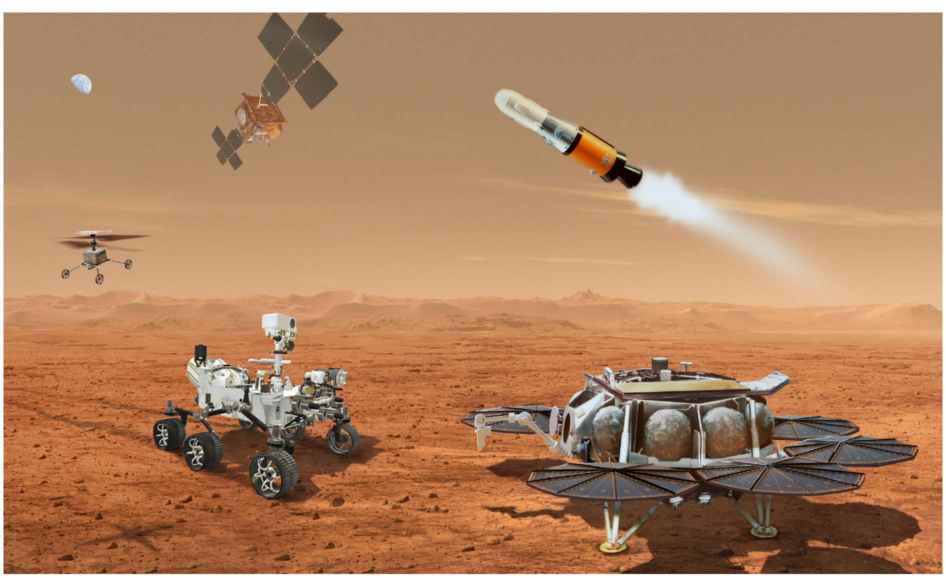
A series of successful Mars-orbiting missions by NASA and other space agencies have mapped the Red Planet in extraordinary detail. The operations of NASA's Mars rovers such as Spirit, Opportunity, and Curiosity have shown that scientists are able to identify and study areas where liquid water could have existed on the surface for significant periods of time.

The challenges of designing, building, landing, and operating these increasingly ambitious missions have driven new developments in technology and built a community of highly experienced scientists and engineers. Their accomplishments have confirmed a consensus that—for the foreseeable future—the best way to find compelling, widely accepted evidence for past life on Mars requires detailed analysis of a diverse set of carefully selected samples using the full range of the best instruments available on Earth.

Science Determines the Priority

NASA's Perseverance Mars rover landed in Jezero Crater in February 2021 and is now collecting and storing a range of compelling samples in specially designed tubes. This accomplishment fulfills many years of external guidance to NASA, including the top recommendation of the U.S. planetary community in their most recent national strategy, titled *Origins, Worlds, and Life: A Decadal Strategy for Planetary Science and Astrobiology 2023-2032.*

Beyond the search for evidence of past life, the combined efforts of Perseverance and potential Mars Sample Return (MSR) missions are expected to help scientists understand the detailed geological history of Mars, the evolution of its climate, and any hazards that could affect future human explorers.



This illustration shows a concept for multiple robots that would team up to ferry to Earth samples of rocks and atmosphere being collected from the Martian surface by NASA's Perseverance Mars rover.

A NASA-ESA Partnership

NASA and the European Space Agency (ESA) have formed a partnership to develop detailed plans for a series of missions that would gather the samples, launch them into Mars orbit, capture and contain them securely, and return them safely to Earth in the early 2030s. Under the proposed MSR program, NASA would develop a Sample Retrieval Lander (SRL) mission, which would launch in 2028 from the Eastern Range in Florida, carrying a rocket known as the Mars Ascent Vehicle (MAV) and two Sample Recovery Helicopters based on the successful Ingenuity helicopter deployed on Mars by Perseverance.

The Perseverance rover is the primary option for delivering the sample tubes to the SRL, where an ESA-provided robotic arm would insert the samples into an Orbiting Sample (OS) container atop the MAV. The helicopters would serve as a secondary option to bring the tubes to the vicinity of the SRL should Perseverance become unable to deliver them.

About the size of a volleyball, the OS would be launched by the MAV into orbit around Mars, where it would meet an Earth Return Orbiter (ERO) built by ESA and launched from French Guiana in 2027. The ERO would rendezvous with and capture the OS in Mars orbit using a NASA-built module aboard the ERO called the Capture, Containment, and Return System (CCRS). Inside the CCRS, the samples would be securely contained using a “container within a container” approach, and then inserted into a return vehicle called the Earth Entry System (EES).

The ERO would transport the cone-shaped EES from Mars to the vicinity of Earth, where a final decision would be made using all available information to validate that the Mars samples remain securely enclosed and that the EES remains in good health. If judged safe to proceed, the ERO would adjust its path, release the EES, and continue past Earth. The EES, about the size of a tire on a semi-truck, would passively enter Earth’s atmosphere on a predictable path shaped by gravity and atmospheric drag. The EES would land in an appropriate, well-characterized area, baselined to be the Utah Test & Training Range.

A “Safety First” Approach

Multiple panels of scientific experts convened over the past two decades have found that the potential risk to Earth’s biosphere from a sample of the surface of Mars is extremely low. The most direct way to ensure that Mars samples do not pose a hazard to our biosphere is to securely contain the samples during their return using a “safety first” engineering approach, which is the basis of NASA-ESA planning for MSR.

Multiple engineering steps are being designed—and rigorously tested—to completely “break the chain” of contact between Mars and Earth, shielding Earth’s environment from any material from Mars that has not been contained or sterilized.

The MSR Program has established strict targets designed to drive engineering decisions and testing toward a commitment to maintaining extremely robust containment. The probability target for containment during the approach, entry, and descent phase is 99.9999 percent. The same targets apply to the interplanetary transit and landing phases.

Backward Planetary Protection

Backward planetary protection is the discipline of safeguarding Earth’s biosphere from any adverse effects that could be caused by returned samples from other planetary bodies. MSR represents the first robotic return to Earth of “restricted” samples that are subject to special procedures because the material comes from a place with the potential for biological activity or even current (“extant”) life.

Techniques to isolate samples of asteroids, comet dust, and the solar wind from Earth materials have been employed on past international space missions. Similar containment procedures would be expanded upon for MSR to include robust systems for isolating returned samples within redundant, sealed containers and ensuring any equipment exposed to Mars material is sterilized prior to its return to Earth. The MSR systems are designed to be resilient to multiple contingencies and capable of aborting the return in the event that safety conditions are not met; the status of the planned isolation measures and the health of spacecraft hardware will be carefully assessed during each step of the mission.

A Secure Lab on Earth

Once landed, the EES would be sealed in a primary enclosure, which would then be installed in a special travel case for secure transportation to a dedicated sample receiving facility. The travel and handling procedures for the EES, and the security and functionality of the receiving facility would be based heavily on the proven techniques used for safely handling biological toxins and known infectious agents used in Earth-based research labs. The samples would be kept under these stringent containment conditions and not released to other laboratories until it is determined that they are safe through extensive analyses or rendered biologically inert through sterilization.

Similar to the lunar samples from the Apollo missions to the Moon, it is expected that the samples to be returned from Mars would be studied in great detail for many decades by future generations of scientists, including instruments and techniques that have not yet been invented.

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