NASA facts

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.

Years of 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. Much of this warmer, wetter period is believed to be ancient, occurring about three billion years ago, in the same geologic timeframe as 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. NASA's Mars rovers such as Spirit, Opportunity, and Curiosity have shown that scientists understand how 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—finding 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.

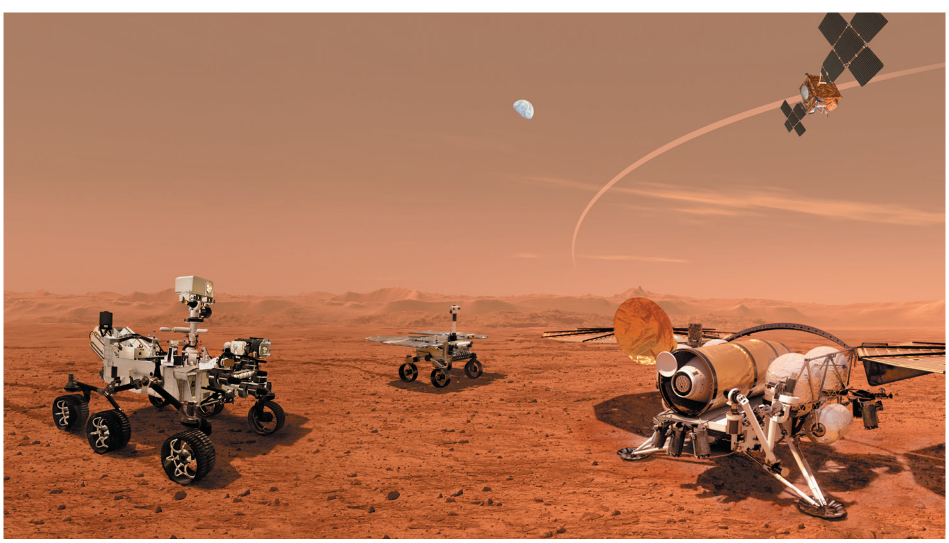
Science Determines the Priority

NASA's Perseverance Mars rover landed in Jezero Crater in February 2021 and is now collecting and storing a range of compelling samples. 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 *Vision and Voyages for Planetary Science in the Decade 2013-2022.*

Beyond the search for 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 in the dust of the Red Planet that could affect future human explorers.

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



This illustration shows a concept for a set of future robotic missions that would work together to ferry back samples from the surface of Mars being collected by NASA's Mars Perseverance rover. Credit: NASA/ESA/JPL-Caltech the proposed MSR program, NASA would develop a Sample Retrieval Lander (SRL) mission, which would launch in 2028 from NASA's Kennedy Space Center, Florida, carrying a rocket known as the Mars Ascent Vehicle (MAV).

A second lander would deliver an ESA-provided and operated Sample Fetch Rover to collect the sample tubes from the Perseverance mission. The fetch rover would bring the tubes back to the second lander, which would use an ESA-provided robotic arm to insert the samples into an Orbiting Sample (OS) container atop the MAV; the Perseverance rover may also deliver sample tubes directly to the lander carrying the MAV and OS.

About the size of a volleyball, the OS would be launched by the MAV into orbit around Mars, where it would meet a solar-powered Earth Return Orbiter (ERO) built by ESA and launched from French Guiana as early as 2026. 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). The CCRS would then seal the OS inside a container while simultaneously using heat to sterilize any surfaces on the container's seal and the sealing mechanism that could have contacted Martian dust. The sealed container would then be passed into a clean chamber that has never been exposed to Mars dust, where it would be sealed inside yet another container, within the Earth Entry System.

The ERO would transport the disk-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. Upon a favorable decision, 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, such as the Utah Test & Training Range.

Breaking the Chain

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 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.

The engineering steps taken ensure effective backward planetary protection 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.

For example the sealing process inside the CCRS that creates a secure container surrounding the OS occurs at a temperature high enough to inactivate microorganisms and even individual proteins inside the small amount of dust that might remain in the joint. After that secure container is passed into a clean enclosure, any un-contained Mars material remaining would be left in Mars orbit by ejecting any other CCRS hardware that contacted the OS before ERO leaves for the return journey to Earth.

Backward Planetary Protection

Backward planetary protection is the discipline of safeguarding Earth's biosphere from any inadvertent hazard that could be found in 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 protect samples of asteroids, comet dust, and the solar wind from Earth materials have been employed successfully on past international space missions. These 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, using instruments and techniques that have yet to be invented.

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