NASA facts

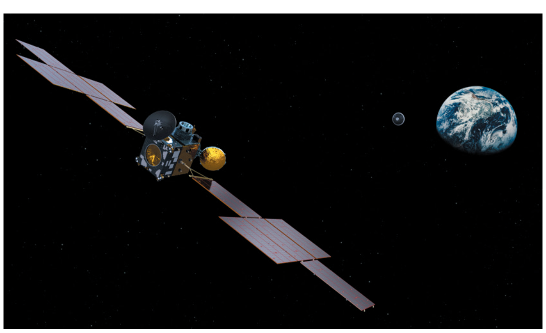
The Safety of Mars Sample Return

Planetary Protection is the discipline of protecting solar system bodies such as planets and moons from possible contamination by Earth life, and protecting Earth's biosphere from any potential adverse effects that could result from bringing material collected from these bodies back to our planet.

The Mars Sample Return (MSR) program being planned by NASA and the European Space Agency (ESA) would pick up the geologic and atmospheric samples being gathered by NASA's Perseverance Mars rover and return them to Earth in the early 2030s. The NASA-ESA team is working closely with each agency's planetary protection leadership to ensure that every spacecraft sent to the Red Planet has been cleaned to prevent Earth organisms from compromising scientific investigations, and to implement numerous steps designed to protect Earth and provide safety assurance by preventing any uncontained, unsterilized Mars material from being delivered to Earth.

Assessing the Risks

The question of whether samples from Mars could present a hazard to Earth's biosphere has been studied by several different panels of scientific experts from the United States and elsewhere over the past several decades. The reports from these panels have found an extremely low likelihood that samples collected from areas on Mars like those being explored by Perseverance could possibly contain a biological hazard to our biosphere.



This artist's concept of a proposed Mars sample return mission portrays the Earth Entry System, bearing a container of Martian rock samples, heading toward Earth after separating from the Earth Return Orbiter spacecraft that carried the entry system and samples from Mars orbit to the vicinity of Earth.
Credit: ESA/ATG Medialab

Multiple different sources of scientific evidence contribute to this assessment. The evidence includes the absence of any observed harm to Earth's environment from Martian rocks that frequently fall to Earth in the form of meteorites, and the fact that the Mars samples being gathered by NASA's Perseverance Mars rover are from the first few inches of a planetary surface that is very dry and highly irradiated naturally by the Sun, which would sterilize all known active biology. (This is part of why NASA's science strategy is focused on finding traces of ancient life from long ago, when the Martian environment was wetter and warmer, and not modern life in these harsh conditions).

A Conservative Engineering Approach

Protecting the public, the NASA workforce, and the environment from potential harm is an integral feature of every agency program and technology development activity. For MSR, the most direct means of protecting Earth's biosphere is to securely contain all unsterilized Mars material returned to Earth, using a multi-layered approach involving a "container within a container."

The standards for safety engineering and containment being implemented for MSR are derived from "safety first" industries such as medicine and aviation. NASA and ESA engineers are focused on designing and delivering a multi-layered containment system capable of bringing Mars samples to Earth safely. The planned approach would provide higher levels of isolation than anything achieved previously in space flight, including for the samples of lunar rocks, comet dust, asteroids, and the solar wind successfully captured and returned to Earth by earlier NASA and international missions.

Breaking the Chain with Mars

Collectively, these containment engineering and verification activities are known as "breaking the chain" of contact with Mars. These processes would include steps taken at every stage of the campaign: on the surface of Mars, in orbit around the Red Planet, in flight between planets, and all the way to the surface of Earth. Each step sequentially reduces the potential that any unsterilized Mars material could be released into Earth's biosphere. Many of the planned protective measures provide layers of redundancy throughout the mission, and would enable safe sample return under a variety of mission conditions.

The process begins on the surface of Mars, where the Orbiting Sample (OS) container is protected from Martian dust by an enclosure that is opened only to insert sample tubes, minimizing the amount of dust that is allowed to accumulate on the OS. Once launched into orbit by the planned Mars Ascent System, the volleyball-sized OS would be collected inside the Capture, Containment and Return System (CCRS), a payload on ESA's Earth Return Orbiter.

As its name suggests, the CCRS first captures the OS and then seals it inside the first of two containment vessels, while simultaneously heat sterilizing any Mars dust that might remain in the seam of this primary containment vessel. The sterilization process would be done at a temperature high enough to destroy protein structures and inactivate any biological material in the small amount of dust that might remain in the joint. Then, the sealed container would be passed into a clean chamber inside the CCRS that has been protected from Mars dust, where it would be sealed inside a secondary containment vessel, which would be then secured within a robustly designed Earth Entry System (EES).

Other elements of breaking the chain include ejecting much of the CCRS hardware from the Earth Return Orbiter before it leaves Mars orbit, and using a micrometeoroid shield to protect the EES during its return trip to Earth aboard the orbiter.

Special Care Before, During, and After Landing

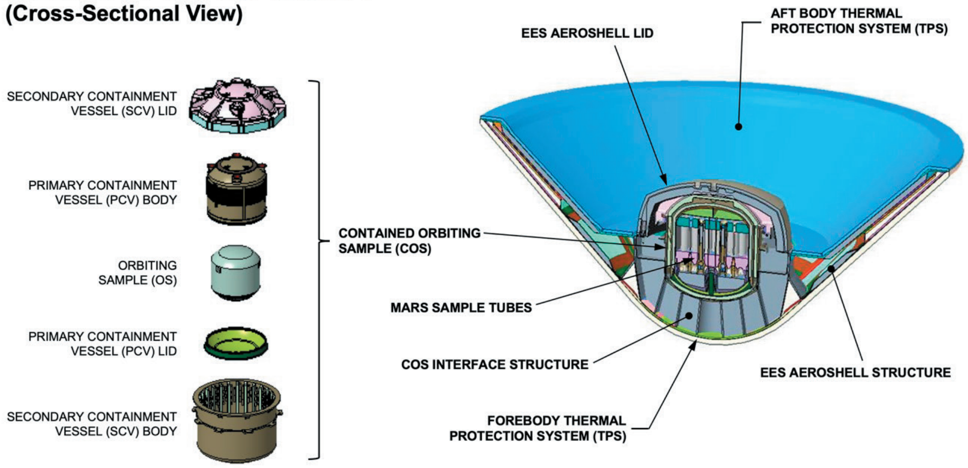
The trajectory of the return orbiter carrying the EES would be pointed away from Earth until a few days before the planned landing, allowing a final decision to be made about proceeding with Earth entry using all available information collected during the entire mission.

The EES is built to tolerate extreme conditions: it would enter the Earth's atmosphere at nearly 27,000 mph, experience forces nearly 125 times greater than gravity while slowing to just 90 mph, and land using only the ground as its cushion. The cone-shaped vehicle and its components, such as the "container within a container" surrounding the OS, are being robustly designed and tested on Earth to demonstrate their ability to withstand forces well beyond those that would be experienced during entry and landing.

Out of an abundance caution, the entry system and its samples would be treated with the highest level of care once having landed, as if they could be hazardous biological materials. The EES will be quickly enclosed in additional layers of containment, using procedures based upon the proven principles and techniques used by hazardous material response teams, and will be maintained through transport to a dedicated Mars sample receiving facility.

Such a Mars sample receiving facility would have design and sample handling requirements equivalent to those of biological safety laboratories used for research studies of infectious diseases. The well-established safety protocols and engineering controls used to isolate hazardous biological materials in such laboratories address issues that are very similar to those involved in Mars sample return. At this time, there are several options under study for implementing a Mars sample receiving facility.

PRELIMINARY MSR EES CONCEPT
(Cross-Sectional View)



The conceptual design of the Earth Entry System (EES) for Mars Sample Return includes redundant layers of containment for the samples and a design that softens the effects of landing without a parachute.

Continuing the fundamental "safety first" approach to MSR, the samples would remain securely contained inside qualified facilities unless they are fully sterilized or until they are determined by rigorous testing to be safe for release to other laboratories and curation facilities. NASA and ESA are collaborating on the sample safety testing framework, which will be subjected to a peer review by outside experts before it would be approved for use in releasing any samples for detailed study.