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It sounds futuristic, but the day could be coming when most test flights leading to a type certification are conducted virtually. Here's how. PAGE 16

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Calls grow for a safer Mars Sample Return

In 2033, NASA and the European Space Agency want to robotically bring home rock and soil samples from Mars. In recent public consultations, however, some suggest diverting samples to a space station or a lunar base to avoid any contamination risk to Earth. Can it work? Paul Marks investigates.

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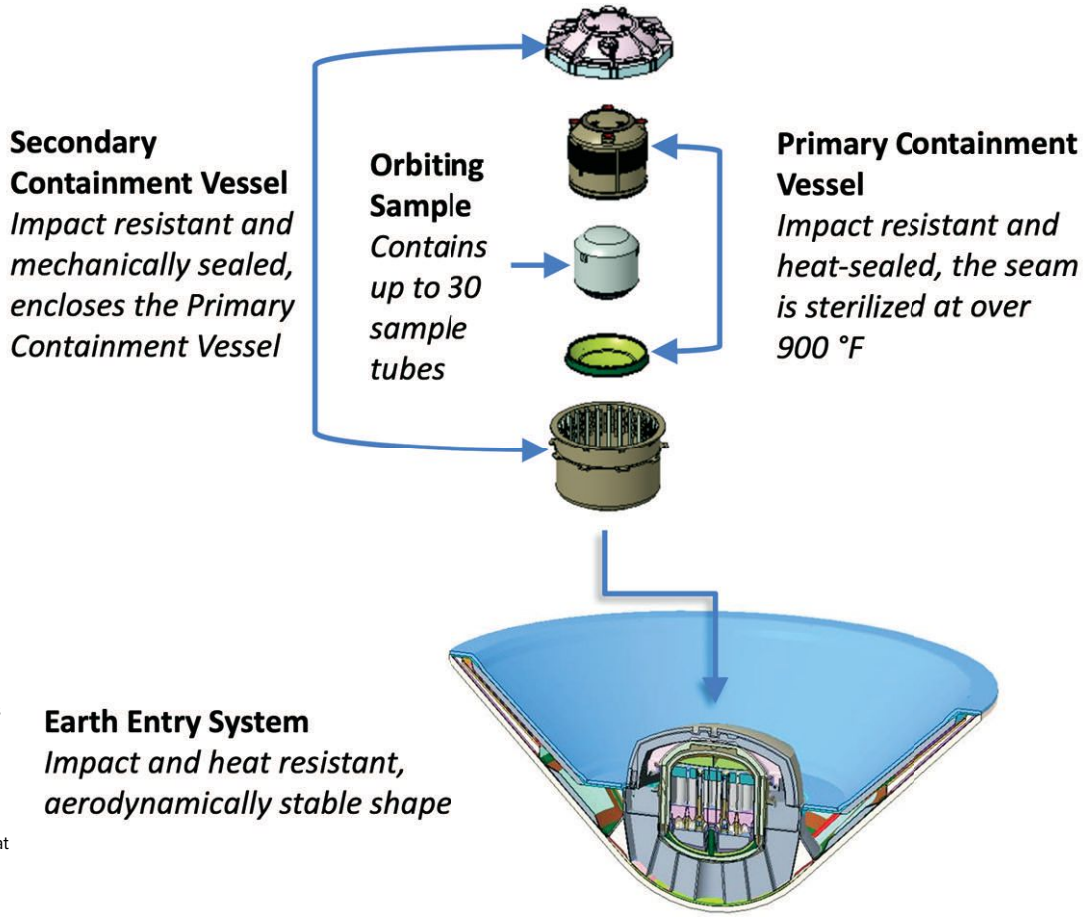
On the face of it, NASA and the European Space Agency's plan to return Martian rock and soil samples to Earth in 2033 seems straightforward enough. On Mars, the Perseverance rover has been collecting rock and soil samples for retrieval by a future rover that will, in turn, insert them in an ascent rocket. The samples will be boosted to Mars orbit to rendezvous with an Earth return orbiter, where they will be captured and wrapped in a containment vessel that's designed to withstand plowing through the atmosphere and thumping to rest on the desert floor.

At least, that's the theory. Mars Sample Return's multidecade spaceflight ballet must be more than the choreography of guidance, dynamics and control. It must also guarantee the safety and security of Earth's biosphere. So thoughts are now turning to whether all the multifarious containment steps can work.

The reason for concern? No one knows what biologically active organisms might exist on Mars, and, if they do exist, whether they pose any threat to life on Earth. After the onset of the covid-19 pandemic, space agencies would not be forgiven for importing a Martian pathogen — perhaps one of unknown extraterrestrial biology that human medicine has no defenses against.

This could happen, says the International Committee Against Mars Sample Return (ICAMSR), a New York-based group of astrobiological environmentalists, if the Earth return sample containment vessel proves inadequate or if the Earth Entry System reentry spacecraft it sits in breaks up on impact, as NASA's Genesis probe did in 2004.



▶ This graphic showed during one of NASA's public briefings on the environmental risks of Mars Sample Return illustrates how the samples would be ensconced inside two vessels within the Earth Entry System spacecraft that would return them to Earth.

NASA

Alternatively, the EES could be breached at altitude — perhaps after a space debris collision — spilling Martian pathogens across the planet as it descends, warns ICAMSR.

Instead, says the group's director Barry diGregorio, a former astrobiologist, the group backs the idea of analyzing Mars samples in a biosecure lab on the International Space Station, NASA's planned Lunar Gateway or a future lunar base.

The alarm over the risks of returning samples from Mars was first sounded in 1973 by Carl Sagan, founder of The Planetary Society who died in 1996. In his book "Cosmic Connections," he wrote that "it is possible that on Mars there are pathogens, organisms which, if transported to the terrestrial environment, might do enormous biological damage — a Martian plague, the twist in the plot of HG Wells' War of the Worlds, but in reverse. This is an extremely grave point."

NASA agrees that there is the "potential for past or present indigenous lifeforms on Mars" to piggyback on returned samples. And in a December 2020 paper in the International Journal of Astrobiology, a 14-person Mars sample Sterilization Working Group convened by NASA says: "The potential risks associated with returning samples from Mars are likely to be low-probability, yet high-consequence risks."

And, the working group notes, sterilizing Mars samples on Mars and Earth (such as with heat and radiation) will be performed "on the basis of biology as we know it," the suggestion being that there's still a chance an alien biology exists that can cope with more extreme conditions than terrestrial microbes.

So, because it is a federal agency, NASA must prepare an environmental impact statement for the Mars Sample Return (MSR) mission. As part of that, it has had to seek the views of the public on the risks involved in its $8 billion mission with ESA.

On April 15, NASA opened itself up to a 30-day public comment period on MSR risks by publishing a public notice in the Federal Register, the U.S. government's official journal, inviting people to post their views online or attend two live virtual NASA briefings where they could also ask questions of NASA's MSR experts and leave comments.

NASA says a draft impact statement will be published, based in part on these comments, and considered in a further 45-day public comment period "in late 2022" — with a final statement to be published in 2023.

Of the 170 public comments received by NASA, some themes emerge: Some said Martian samples should not come to Earth but rather should be analyzed on a space station or a lunar base. Others were incred-

▲ NASA's Langley and Ames research centers are leading development of the disk-shaped Earth Entry System spacecraft and heat shield that would protect the sealed container of Martian dirt and rocks samples as they plow through the atmosphere upon return to Earth. Engineers in April dropped a test article of the heat shield outfitted with sensors from an altitude of 365 meters to simulate the impact.

NASA

ulous at the perceived audacity of NASA's plan, as the havoc that invasive species cause between nations is already well known: "I cannot even bring fruit into the U.S. from Mexico!" says one. Others say all such analysis should be done on Mars itself.

Some example comments include:

- "Bringing Martian soil back to earth to study is irresponsible. We have a perfectly good space station. Can we study it there first?"
- "Stage initial microbial analysis of Mars samples on the Moon, or an isolated module on the ISS."
- "We know relatively very little about Mars, much less the bacteria, organisms or viruses Mars hosts. [Bring them to] the Lunar Gateway instead."

But listening to such views and acting on them are two different things, and observers say it is unclear how much NASA is willing or able to be swayed, if at all, by ideas of samples returning to space stations or the moon, especially in light of the costs already sunk into MSR's Earth-return mission architecture.

In any case, analyzing Mars samples in a high-containment biosafety-level-4 lab (BSL-4) on a space station is far tougher than it sounds, says Cassie Conley, a NASA astrobiologist who studied the matter as the agency's planetary protection officer from 2006 until 2018.

"Building instruments to operate in microgravity is extremely challenging, and the reliability, sensitivity and accuracy of microgravity instrumentation is much lower than the same instruments on Earth," Conley told me by email. "The sorts of instrumentation failures that often happen on the ISS would make this impossible."

"If somehow these cost and technical concerns were solved, the only location that would make sense for an orbiting facility would be in a fail-safe orbit near one of the Lagrange points — where the orbit would decay away from the Earth-Moon system if the facility lost power."

And Conley says placing a lab with equivalent containment to a BSL-4 lab on the moon could be problematic if it fails and leaks. "To preserve the ability for humans to travel between the Earth and the Moon, without needing decontamination protocols, it would be nearly as bad if the Moon got contaminated, as if the Earth were," she says.

"So if there is anything hazardous in Mars samples, a failed facility could not be allowed to contaminate either the Moon or the Earth."

Wherever Mars samples eventually travel to after reaching Mars orbit — be it Earth, a space station or the moon — the package of 30 sealed tubes of rock and soil samples sent up by the Mars Ascent Vehicle rocket has to be encapsulated in such a way that any Martian dust on it is completely contained within some kind of all-encompassing shroud.

Until now, that was to have been done by robotically brazing a containment vessel around the sample package while in orbit. But in NASA's environmental presentation on May 4, it was revealed that this highly experimental method has now been abandoned.

"It represents an option we considered, but chose not to implement," says Brendan Feehan, mission systems engineer on MSR's Capture, Containment, and Return System.

"We have moved to a heated shrink-fit design for sealing the primary containment vessel," he says.

It is not entirely clear yet how this heat shrink technology works, but it appears to be a more reliable sealing method than what was essentially an unwieldy, automated welding-based technique.

At ICAMSR, however, diGregorio is unimpressed by this technological switch. "This is just NASA avoiding the issue — using Earth as a Mars Sample Return reception point to make it cost efficient and easier to do rather than sending it to the Lunar Gateway," he says.

"It's putting cost ahead of safety again." ★