

Let's go on an ESCAPADE – NASA's small, low-cost orbiters will examine Mars' atmosphere

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This close-up illustration shows what one of the twin ESCAPADE spacecraft will look like conducting its science operations.

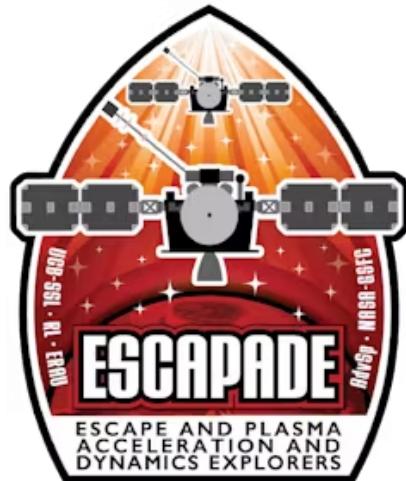
James Rattray/Rocket Lab USA/Goddard Space Flight Center

Envision a time when hundreds of spacecraft are exploring the solar system and beyond. That's the future that NASA's ESCAPADE, or escape and plasma acceleration and dynamics explorers, mission will help unleash: one where small, low-cost spacecraft enable researchers to learn rapidly, iterate, and advance technology and science.

The ESCAPADE mission will launch in mid-November 2025 on a Blue Origin New Glenn rocket, sending two small orbiters to Mars to study its atmosphere. As aerospace engineers, we're excited about this mission because not only will it do great science while advancing the deep space capabilities of small spacecraft, but it also will travel to the red planet on an innovative new trajectory.

The ESCAPADE mission is actually two spacecraft instead of one. Two identical spacecraft will take simultaneous measurements, resulting in better science. These spacecraft are smaller than those used in the past, each about the size of a copy machine, partly enabled by an ongoing miniaturization trend in the space industry. Doing more with less is very important for space exploration, because it typically takes most of the mass of a spacecraft simply to transport it where you want it to go.

Having two spacecraft also acts as an insurance policy in case one of them doesn't work as planned. Even if one completely fails, researchers can still do science with a single working spacecraft. This redundancy enables each spacecraft to be built more affordably than in the past, because the copies allow for more acceptance of risk.



The ESCAPADE mission logo shows the twin orbiters.

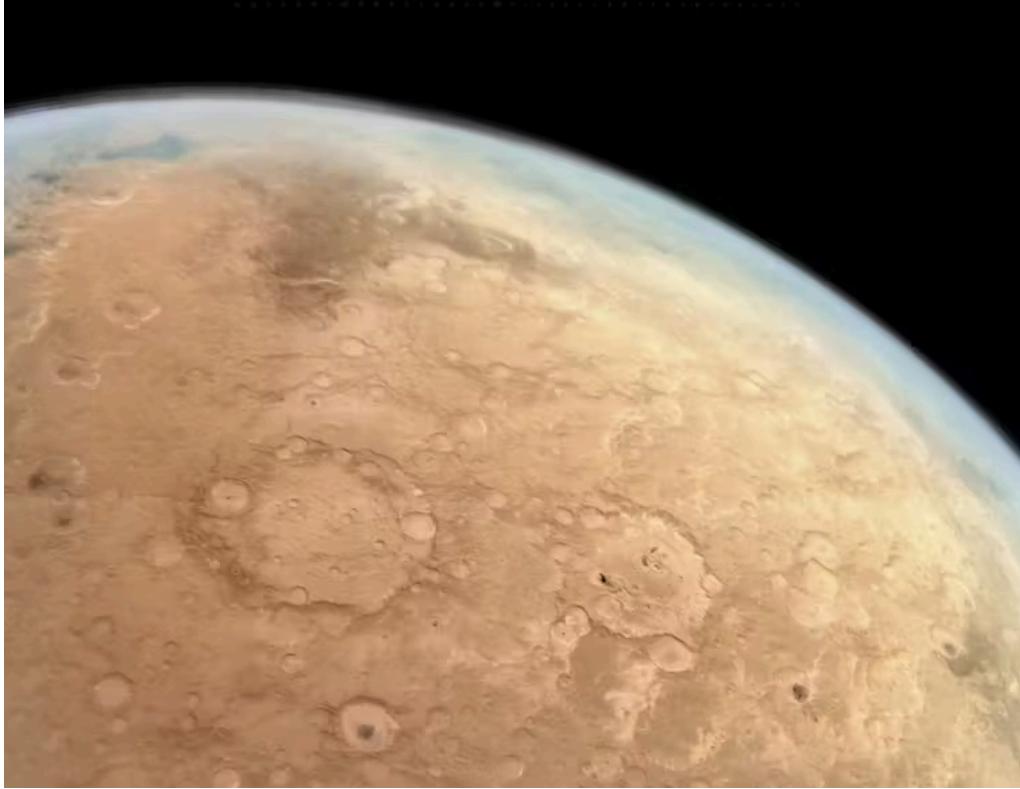
TRAX International/Kristen Perrin

Studying Mars' history

Long before the ESCAPADE twin spacecraft Blue and Gold were ready to go to space – billions of years ago, to be more precise – Mars had a much thicker atmosphere than it does now. This atmosphere would have enabled liquids to flow on its surface, creating the channels and gullies that scientists can still observe today.

But where did the bulk of this atmosphere go? Its loss turned Mars into the cold and dry world it is today, with a surface air pressure less than 1% of Earth's.

Mars also once had a magnetic field, like Earth's, that helped to shield its atmosphere. That atmosphere and magnetic field would have been critical to any life that might have existed on early Mars.



Today, Mars' atmosphere is very thin. Billions of years ago, it was much thicker.

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ESCAPADE will measure remnants of this magnetic field that have been preserved by ancient rock and study the flow and energy of Mars' atmosphere and how it interacts with the solar wind, the stream of particles that the sun emits along with light. These measurements will help to reveal where the atmosphere went and how quickly Mars is still losing it today.

Weathering space on a budget

Space is not a friendly place. Most of it is a vacuum – that is, mostly empty, without the gas molecules that create pressure and allow you to breathe or transfer heat. These molecules keep things from getting too hot or too cold. In space, with no pressure, a spacecraft can easily get too hot or too cold, depending on whether it is in sunlight or in shadow.

In addition, the Sun and other, farther astronomical objects emit radiation that living things do not experience on Earth. Earth's magnetic field protects you from the worst of this radiation. So when humans or our robotic representatives leave the Earth, our spacecraft must survive in this extreme environment not present on Earth.

ESCAPADE will overcome these challenges with a shoestring budget totaling US\$80 million. That is a lot of money, but for a mission to another planet it is inexpensive. It has kept costs low by leveraging commercial technologies for deep space exploration, which is now possible because of prior investments in fundamental research.

For example, the GRAIL mission, launched in 2011, previously used two spacecraft, Ebb and Flow, to map the Moon's gravity fields. ESCAPADE takes this concept to another world, Mars, and costs a fraction as much as GRAIL.

Led by Rob Lillis of UC Berkeley's Space Sciences Laboratory, this collaboration between spacecraft builders Rocket Lab, trajectory specialists Advanced Space LLC and launch provider Blue Origin – all commercial partners funded by NASA – aims to show that deep space exploration is now faster, more agile and more affordable than ever before.

How will ESCAPADE get to Mars?

ESCAPADE will also use a new trajectory to get to Mars. Imagine being an archer in the Olympics. To hit a bull's-eye, you have to shoot an arrow through a 15-inch – 40-centimeter – circle from a distance of 300 feet, or 90 meters. Now imagine the bull's-eye represents Mars. To hit it from Earth, you would have to shoot an arrow through the same 15-inch bull's-eye at a distance of over 13 miles, or 22 kilometers. You would also have to shoot the arrow in a curved path so that it goes around the Sun.

Not only that, but Mars won't be at the bull's-eye at the time you shoot the arrow. You must shoot for the spot that Mars will be in 10 months from now. This is the problem that the ESCAPADE mission designers faced. What is amazing is that the physical laws and forces of nature are so predictable that this was not even the hardest problem to solve for the ESCAPADE mission.

It takes energy to get from one place to another. To go from Earth to Mars, a spacecraft has to carry the energy it needs, in the form of rocket fuel, much like gasoline in a car. As a result, a high percentage of the total launch mass has to be fuel for the trip.

When going to Mars orbit from Earth orbit, as much as 80% to 85% of the spacecraft mass has to be propellant, which means not much mass is dedicated to the part of the spacecraft that does all the experiments. This issue makes it important to pack as much capability into the rest of the spacecraft as possible. For ESCAPADE, the propellant is only about 65% of the spacecraft's mass.

ESCAPADE's route is particularly fuel-efficient. First, Blue and Gold will go to the L2 Lagrange point, one of five places where gravitational forces of the Sun and Earth cancel out. Then, after about a year, during which they will collect data monitoring the Sun, they will fly by the Earth, using its gravitational field to get a boost. This way, they will arrive at Mars in about 10 more months.

This new approach has another advantage beyond needing to carry less fuel: Trips from Earth to Mars are typically favorable to save fuel about every 26 months due to the two planets' relative positions. However, this new trajectory makes the departure time more flexible. Future cargo and human missions could use a similar trajectory to have more frequent and less time-constrained trips to Mars.

ESCAPADE will be a testament to a new era in spaceflight. For a new generation of scientists and engineers, ESCAPADE is not just a mission – it is a blueprint for a new collaborative era of exploration and discovery.

Christopher E. Carr is part of the science team for the Rocket Lab Mission to Venus (funding from Schmidt Sciences and NASA). More information is available at <https://www.morningstarmissions.space/rocketlabmissiontovenus>

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