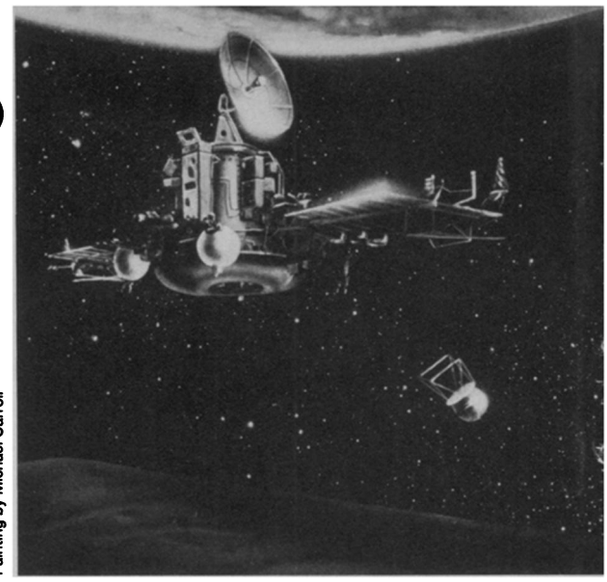
Phobos: Mission to a Martian Potato



Painting by Michael Carroll

From its orbit around Mars, one of the two principal spacecraft of the upcoming Soviet Phobos mission jettisons a tiny "hopper," designed to drop onto the little Martian moon and spring across the surface in 20-yard leaps, taking measurements at a series of sites.

By JONATHAN EBERHART

If you can jump from the floor of your earthbound study to the top of your desk, gaining enough altitude on the way for your feet to be above the desktop with your legs hanging straight down, you could jump into orbit from the surface of Phobos. In fact, you wouldn't have to settle for just an orbit around the little Martian moon — you could end up circling Mars itself.

Phobos is tiny, with less than 1/500th of earth's "average diameter" (a term sometimes necessary when describing an irregular moon whose shape more resembles a potato than a ball) and a mass about 1.6 *billionths* of earth's. A 150-pound earthling on Phobos would weigh about 1 ounce.

Yet if all goes as planned, this little dark-gray rock — roughly (to put it mildly) 14 miles across — will soon become the fourth extraterrestrial body on which spacecraft from earth have landed. Two separate launchings are to take place early next month from the Soviet Union, each sending aloft an unusual combination of craft that will not only land on Phobos but also poke holes in it, zap it from orbit with lasers and ion beams, and hop across its surface.

The two multipurpose spacecraft of the Soviet mission, which is called simply "Phobos," are to lift off on July 7 and 12, reaching the vicinity of Mars about 200 days later. The second craft was originally intended to visit the other, and even tinier, Martian moon, Deimos, though the Soviets now apparently plan to send both to Phobos.

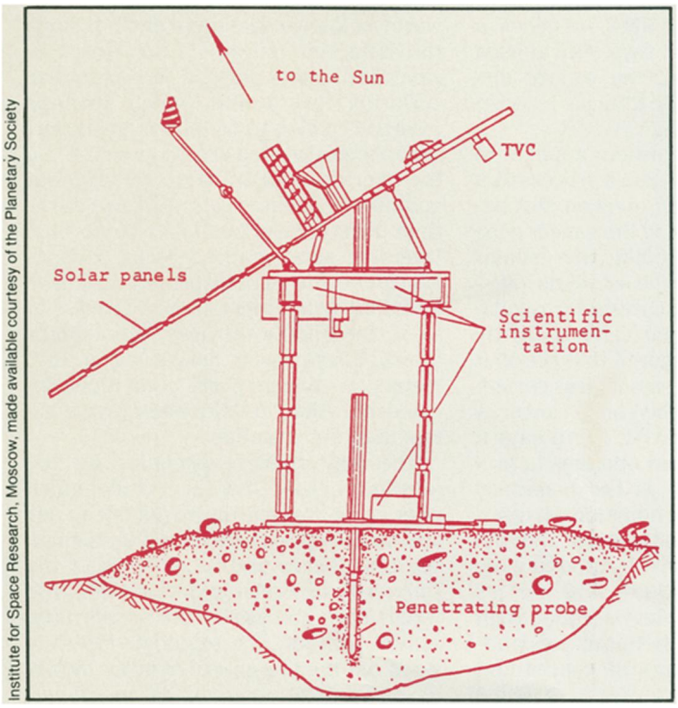
The mission is the most complex interplanetary endeavor yet attempted by the Soviets, whose spacecraft in the past have roved across the surface of earth's moon (without cosmonauts in the driver's seat) and briefly survived on Venus despite 900°F temperatures and an atmospheric pressure equivalent to that more than half a mile down in a terrestrial ocean.

The Phobos vehicles will be the first sent toward Mars since the resoundingly successful U.S. Viking orbiters and landers reached the planet in the summer of 1976. Several Soviet Mars-landing attempts, all of them prior to Viking, ended variously by crashing into their destination, missing it completely, ending their transmissions on the way down and, in the case of Mars 3 in 1971, sending data from the surface for less than a minute. The last two Soviet craft to head for Mars (Mars 6 and 7) got there in 1974, with one providing descent data only and the other releasing a lander that missed the planet by nearly 900 miles.

Since that time, a repeated Soviet success story has been its missions to the planet Venus, involving orbiters that radar-mapped the cloud-shrouded surface, balloons that tracked winds in the atmosphere, and landing craft that analyzed the rock and took color photos of the terrain. Now, however, the focus is back on Mars.

The only presently approved U.S. Mars mission is called the Mars Observer, an orbiter scheduled to be launched in 1992 and which, if it lasts long enough, could result in scientific operations going on at the same time as those of an elaborate Soviet mission due in 1994. When President Reagan and Soviet Secretary General Gorbachev agreed at the recent Moscow summit meeting to an initiative for expanded cooperation on civilian space activities (SN: 6/11/88, p.374), they noted scientific missions to Mars as an area of possible bilateral and international cooperation.

The imminent Soviet Phobos mission calls for two spacecraft, each of which includes a lander and a surface-hopper, to head for Mars and settle into a long, elliptical orbit around the planet. The first craft's ellipse will be



Institute for Space Research, Moscow; made available courtesy of the Planetary Society

Unlike the peripatetic hopper, the landing craft of the Phobos mission is equipped with a "penetrator" both to hold the lander down in the extremely weak gravitational field and to measure the physical properties of the surface material.

adjusted to an approximately 6,000-mile-high circle. After checking the motions of Phobos with a series of careful navigation measurements — made with the help of the U.S. Deep Space Tracking Network — flight controllers will lower the height of the circle to about 5,840 miles, so that the spacecraft and Phobos will revolve around Mars almost together. The other spacecraft will stay in its elliptical orbit, studying Mars, until after the first one's activities are underway.

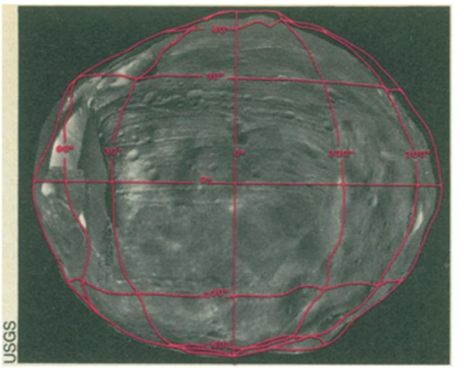
Then the intricacies of the mission begin in earnest. The first of the orbiters will be guided to hover between perhaps 250 feet and 100 feet above the little moon's surface, moving slowly across it at about 5 to 10 miles per hour and turning on its vertical axis to make a detailed, wide-angle photographic survey of the face of Phobos. Soviet studies suggest the pictures could have a resolution of less than a centimeter with the orbiter 50 meters up. The plan calls for the orbiter to carefully follow the ups and downs of the terrain for about 20 minutes, using a technique not unlike one developed for a very different kind of aerospace application. Said Roald Z. Sagdeev of the Soviet Academy of Sciences' Space Research Institute in Moscow, speaking at a recent gathering at the U.S. National Academy of Sciences in Washington, D.C., "I hate this analogy, but I am stuck with it — a cruise missile."

The orbiter will do more than take pictures. Its scientific instruments include a pair designed for what amounts to sampling the composition of Phobos without ever landing on it. One is a laser, with a beam 1 millimeter in diameter, which can vaporize a tiny spot on the surface while an instrument called a "reflectron" analyzes the atomic masses of the elements in the resulting vapor. The other instrument emits a beam of krypton ions, while a mass spectrometer "reads" the secondary ions given off by the surface material in response.

In addition, the orbiter will carry a radar transmitter to conduct soundings into the surface of Phobos in hopes of learning about its structure.

While the orbiter does its work overhead, two much smaller craft will attempt the subtle task of landing on the surface. Because there will be so little gravity pulling it down to a firm footing, a "long-lived autonomous lander" will be lowered not by gentle "retro-rockets" that brake its fall, but by nozzles that fire upward to force it down. Then it will shoot a harpoon-like "penetrator" into the surface. To keep the lander from being driven up again by the reaction, it will be connected to the penetrator by a flexible line that is then automatically reeled in to pull the craft back to the surface.

Though no spacecraft has yet actually sampled the stuff of Phobos, Sagdeev and his colleagues note that the penetrator ought to be capable of punching several



Phobos' irregular shape results in wiggly lines instead of the normally smooth map grid when a mosaic of Viking photos is projected onto a sphere. The result is, according to Ray Batson of the U.S. Geological Survey in Flagstaff, Ariz., an orthographic-map projection that "looks more like a 'potato-graphic.'"

yards into "soft, loose soil," or about a half-yard into something like sandstone. The craft will get its power from solar panels, which will not be unfolded until the dust from the landing has settled or escaped into space. Thereafter, the panels' angle to the sun will be updated every two weeks, guided by a signal from an optical sensor. Soviet space officials hope the lander, which is capable of transmitting directly to earth (rather than having to depend on the orbiter to relay messages), will be able to operate on Phobos for as long as a 687-day Martian year.

Various instruments such as X-ray and alpha-backscatter spectrometers will study the surface composition, while a camera takes closeups. In addition, the role of the lander as a fixed radio beacon will allow a number of experiments in celestial mechanics, such as detailed measurements of the motions of Phobos relative to Mars. Phobos is gradually drawing closer to the planet, for example, and many astronomers expect the little moon to disintegrate in a few tens of millions of years as the result of gravitational stresses.

One of the frustrations of scientists working with the U.S. Viking landers on Mars was the fact the craft could not simply get up and move, essentially to see what might be over the next hill. The Phobos mission, however, is equipped to go literally hopping around, repeating some of its tests at different locations.

The domed hopper will be dropped from the orbiter onto the moon's surface as accelerometers measure the force of the impact. Then a group of rods will unfold to straighten it into its proper working position from whatever orientation in which it happens to land. An X-ray fluorescence spectrometer will report on the chemical composition of the surface while a "penetrometer" measures the physical and mechanical properties of the material underfoot. When the hopper finishes at its initial site, its legs will be drawn up and resprung to kick it to a new site. It is expected to be able to hop more than 20 yards at a time, though project officials are unsure just how many hops will be possible.

The hopper even carries a magnetometer, on the slim chance Phobos might have a magnetic field. Even if such a field exists, Sagdeev and his colleagues note, it would not necessarily reflect original conditions on Phobos. One possibility, they suggest in an English-language description of the mission, is that the little moon could have been "demagnetized partially or remagnetized due to an impact with a large meteorite." The most conspicuous feature on the surface, in fact, is a 6-mile-wide crater known as Stickney, which is more than a third the diameter of Phobos itself and which might be evidence of just such a blow.

It is also unclear whether Mars itself has a magnetic field. The Viking spacecraft carried no magnetometers, and some U.S. scientists dispute data from past Soviet spacecraft cited by some Soviet researchers as evidence for a Martian magnetic field. The Phobos orbiters carry magnetometers to take a definitive look.

In addition, one of the major unsolved questions about the planet is evoked by its rust-red hue. Did Mars once have much more water than it does today? A valuable clue would be the ratio of hydrogen to deuterium, or "heavy hydrogen," in the Martian atmosphere, and the orbiters each carry a spectrometer that mission scientists say may be capable of providing such a measurement.

The Phobos craft also carry instruments to detect cosmic gamma-ray bursts, as well as to conduct studies of the sun ranging from X-ray images of the corona to measurements of the pulsations in the sun's diameter.

Phobos and Mars are the point of the mission, but a host of other issues are associated with the endeavor. They range from how soon the U.S. planetary program will be able to get off the ground again, following the disastrous Challenger explosion nearly 29 months ago, to whether ideas of expanded Soviet-U.S. cooperation in space will indeed come to fruition.

More than a dozen countries are involved in the Phobos project, including several member-nations of the European Space Agency, and several U.S. researchers are serving as scientists with the mission, including working on individual experiments as co-investigators. Still unknown, however, is whether the two superpowers will decide to collaborate on the much more elaborate and costly — indeed, audacious — objective of multinational human exploration of another world. □