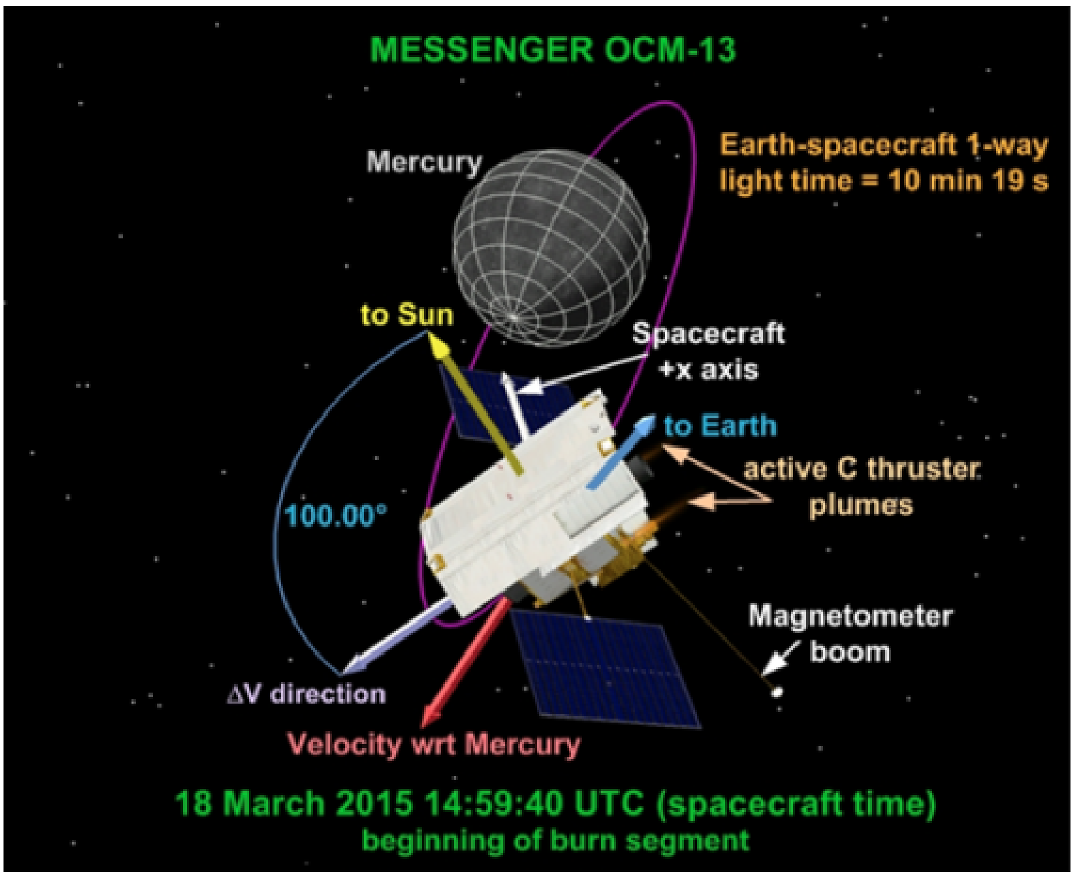
MESSENGER's endgame: Hover campaign promises bird's-eye view of Mercury's surface

March 19 2015



MESSENGER will not go gentle into that good night. The mission will end sometime this spring, when the spacecraft runs out of propellant and the force of solar gravity causes it to impact the surface of Mercury. But the team initiated a "hover" observation campaign designed to gather scientific data from the planet at ultra-low altitudes until the last possible moment. Engineers have devised a series of orbit-correction maneuvers (OCMs) over the next five weeks—the first of which was carried out today—designed to delay the inevitable impact a bit longer.

A highly accurate OCM executed on January 21 targeting a 15-kilometer periapsis altitude—the lowest to date—set the stage for the hover campaign, in a short extension of the Second Extended Mission termed XM2-Prime (XM2'). The top science goals for XM2' will be carried out with the Magnetometer (MAG) and the Neutron Spectrometer (NS), and each instrument will target different objectives in different regions, explained MESSENGER Deputy Project Scientist Haje Korth, of The Johns Hopkins University Applied Physics Laboratory (APL), in Laurel, Md.

"With MAG, we will look for crustal magnetic anomalies," he said. "For instance, we have seen hints of crustal magnetization at higher altitudes (~70 kilometers) over the northern rise in Mercury's northern smooth plains. We will revisit this region at lower altitudes during XM2'. There may be other regions where such signals can be observed, and we will be looking for them."

"With NS, scientists will hone in on shadowed craters at northern high latitudes to search for water ice," Korth said. "We have found such evidence previously in the mission, but we hope to find more at low altitudes and spatially resolve the distribution within individual craters if we are lucky."

According to Korth, the observations enabled by this "saving throw" are no less significant than earlier ones. "Establishing the presence of crustal magnetic anomalies on Mercury would be a huge result, because it would extend the known temporal baseline for Mercury's internal magnetic field by eight orders of magnitude," he said. "Moreover, observing any such anomalies at different altitudes will allow the depth of the source to be determined."

"Since the periapsis altitude during the hover campaign is ~30 kilometers or less throughout XM2', we will have the opportunity to map half the planet with a magnetic magnifying glass, so to speak," he continued. "There are regions we have never seen at such low altitudes, and multiple areas of magnetic anomalies may be detected."

Staying Aloft

The ever-present tug of the Sun's gravity continues to perturb the spacecraft's orbit and drive closest approach downward toward the planet surface. For the last few weeks MESSENGER's altitude at closest approach has remained between 13 and 17 kilometers. To extend this hover campaign as long as possible, MESSENGER's mission design team optimized the trajectory design and the placement of each orbit-correction maneuver.

"We decided on a strategy that includes five maneuvers in as many weeks to keep the spacecraft within a tight altitude range of 5 to 39 kilometers above the surface of Mercury at closest approach," said APL's Jim McAdams, MESSENGER's Mission Design Lead Engineer.

Four of these five maneuvers occur in situations different from the dawn-dusk orbit orientation used for all earlier orbit-correction maneuvers in the mission, McAdams said. "During the interplanetary cruise phase, we designed similar course-correction maneuvers consisting of two or three separate, closely spaced maneuvers accomplished with different thruster sets. For XM2', we simplified the design and implementation of the final maneuvers, so that each will be executed at a single spacecraft orientation using one thruster set to maximize the orbit altitude change per unit mass of propellant consumed."

The maneuvers are not without risk, McAdams explained. "Increased uncertainty associated with effects on the spacecraft orbit of Mercury's gravity field at lower-than-ever altitudes, challenges in accurately predicting the spacecraft orbit when the Sun is near the spacecraft-to-Earth communications direction, and implementation of frequent OCMs make for a challenging final few weeks of flight operations," he said. "Depending on how each maneuver goes and on how Mercury's gravity field affects the minimum orbital altitude, we may need to plan and implement a contingency maneuver. Inserting a contingency maneuver will increase the likelihood of the hydrazine propellant running out earlier than planned."

So Far, So Good

This first maneuver went as planned. At the time of this most recent operation, MESSENGER was in an orbit with a closest approach of 11.6 kilometers (7.2 miles) above the surface of Mercury. With a velocity change of 3.07 meters per second (6.87 miles per hour), the spacecraft's four largest monopropellant thrusters (with a small contribution from four of the 12 smallest monopropellant thrusters) nudged the spacecraft to an orbit with a closest-approach altitude of 34.5 kilometers (21.4 miles).

This maneuver also increased the spacecraft's speed relative to Mercury at the maximum distance from Mercury, adding about 1.1 minutes to the spacecraft's eight-hour, 16.5-minute orbit period. OCM-13 used propellant from the small auxiliary fuel tank. This view shows MESSENGER's orientation at the start of the maneuver.

MESSENGER was 185.6 million kilometers (115.4 million miles) from

Earth when the 32-second maneuver began at 11:00 a.m. EDT. Mission controllers at APL verified the start of the maneuver 10.3 minutes later, after the first signals indicating spacecraft thruster activity reached NASA's Deep Space Network tracking station in Goldstone, California.

The next maneuver, on April 2, will again raise the spacecraft's minimum altitude, allowing scientists to continue to collect images and data from MESSENGER's instruments.

Provided by Johns Hopkins University