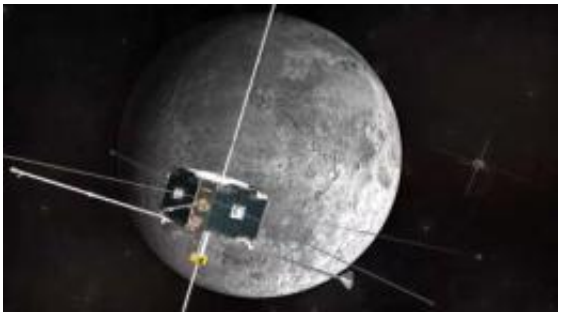
Out of THEMIS, ARTEMIS: Earth's loss is moon's gain

October 27 2010, By Robert Sanders



An artist's concept of one of the twin ARTEMIS probes in orbit around the moon. Formerly part of the THEMIS suite of five probes in Earth orbit, these two micro-satellites will now observe the solar wind's impact on the Earth's magnetic field at a much greater distance from Earth, and the wake left by the moon as it travels through the magnetosphere. Credit: NASA Goddard Space Flight Center

(PhysOrg.com) -- Two micro-satellites originally launched into Earth's orbit in 2007 by NASA have been redirected by University of California, Berkeley, scientists toward new orbits around the moon, extending study of the earth and moon's interaction with the solar wind.

The second of the two probes settled into a temporary "Lagrange-point" orbit on Friday, Oct. 22, inaugurating science operations for a new mission dubbed ARTEMIS – Acceleration, Reconnection, Turbulence, and Electrodynamics of the Moon's Interaction with the Sun.

Lagrange points are places where the gravity of Earth and the moon balance, creating a sort of gravitational parking lot for spacecraft. The two probes will remain there for six months before transitioning to their final, lunar orbits.

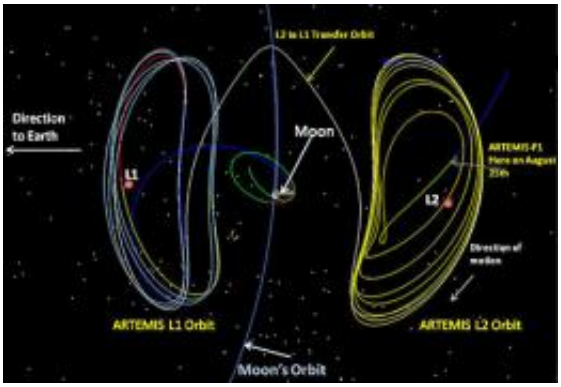
Over the next several years, ARTEMIS will help space scientists understand how the earth's magnetosphere is shaped by the strong solar wind at the distance of the moon and also how the moon's own tiny magnetic field interacts with the solar wind. Using simultaneous measurements of particles and electric and magnetic fields from two locations, ARTEMIS will provide the first three-dimensional perspective of how energetic particle acceleration occurs near the moon's orbit, in the distant magnetosphere, and in the solar wind.

"We currently know very little regarding the space environment of the moon, despite a number of existing and planned observatories there," said Vassilis Angelopoulos, principle investigator for the ARTEMIS mission and a professor of space physics at UCLA. "ARTEMIS is on stable orbits and can provide valuable information regarding the space environment, especially during the approaching solar maximum, as well as fully explore the earth's environment at lunar distances for the first time."

The two probes were originally part of NASA's five-probe THEMIS (Time History of Events and Macroscale Interactions during Substorms) mission, built and operated by UC Berkeley to orbit Earth and determine how storms in the earth's magnetic field disturb the colorful auroras in the Northern and Southern hemispheres.

THEMIS completed is primary mission in 2008 when Angelopoulos announced, "We discovered what makes the Northern Lights dance." The THEMIS team then proposed that the two outermost of the five probes use their extra fuel to propel themselves, via complex maneuvers

around the moon and Earth, into lunar orbits – the first two-satellite mission to the moon. The maneuvers would also save the solar-powered spacecraft, which were spending more and more time in the earth's shadow and, for lack of power, in danger of freezing to death.



The two ARTEMIS probes will orbit for about six months around the Lagrange points near the moon before descending to final orbits around the moon. The Lagrange points are places where the gravity of the Earth and moon cancel one another, creating a sort of parking lot for satellites or debris. (Image: NASA Goddard Space Flight Center)

After approval from NASA, Angelopoulos and his UC Berkeley team, which operates the fleet of satellites from the campus's Space Sciences Laboratory (SSL), began to reposition the two probes on July 20, 2009. The first probe (P1) settled into an orbit around the L2 Lagrange point, located on the far side of the moon, on Aug. 25, 2010, and is now joined by the second (P2) in orbit around the L1 Lagrange point between Earth and moon.

"ARTEMIS is going where no spacecraft have gone before," said Manfred Bester, director of operations at SSL. "We are exploring the Earth-moon Lagrange points for the first time."

Because the Lagrange points lie just outside Earth's magnetosphere, they are excellent places from which to study the solar wind. Particle and field sensors onboard the ARTEMIS probes have access to solar wind streams and storm clouds as they approach Earth, a possible boon to space weather forecasters. Moreover, working from opposite Lagrange points, the two spacecraft will be able to measure solar wind turbulence on scales never sampled by previous missions.

"ARTEMIS is going to give us a fundamental new understanding of the solar wind," predicted David Sibeck, ARTEMIS project scientist at the Goddard Space Flight Center in Maryland.

ARTEMIS will also explore the moon's plasma wake – a turbulent cavity carved out of the solar wind by the moon itself, akin to the wake just behind a speedboat. Sibeck called this "a giant natural laboratory filled with a whole zoo of plasma waves waiting to be discovered and studied."

Plasmas are hot, ionized clouds of gas that can carry electromagnetic and electrostatic waves.

Another target of the ARTEMIS mission is Earth's magnetotail. Like a wind sock at an airport, Earth's magnetic field is elongated by the action of the solar wind, forming a tail that stretches to the orbit of the moon and beyond. Once a month around the time of the full moon, the ARTEMIS probes will follow the moon through the magnetotail.

"We are particularly hoping to catch some magnetic reconnection events," says Sibeck. "These are explosions in Earth's magnetotail that mimic solar flares, albeit on a much smaller scale."

ARTEMIS might even see giant 'plasmoids' accelerated by the explosions hitting the moon during magnetic storms. Plasmoids are self-contained balls of plasma and magnetic field that can carom off

reconfiguring planetary magnetic fields in space like billiard balls.

These far-out explorations may have down-to-Earth applications, Angelopoulos said. Plasma waves and reconnection events pop up on Earth, such as in experimental fusion chambers. Fundamental discoveries by ARTEMIS could help advance research in the area of clean renewable energy.

After six months at the Lagrange points, ARTEMIS will move in closer to the moon, at first only 100 kilometers from the surface, but eventually even closer. From point-blank range, the spacecraft will look to see what the solar wind does to a rocky world when there is no magnetic field to protect it.

"Earth is protected from solar wind by the planetary magnetic field," explained Angelopoulos. "The moon, on the other hand, is utterly exposed. It has no global magnetism."

Studying how the solar wind electrifies, alters and erodes the moon's surface could reveal valuable information for future explorers and give planetary scientists a hint of what's happening on other unmagnetized worlds around the solar system.

Orbiting the moon is notoriously tricky because of irregularities in the lunar gravitational field. Enormous concentrations of mass – mascons – hide just below the surface and tug on spacecraft in unexpected ways, causing them over time to veer out of orbit, Angelopoulos said. ARTEMIS will mitigate this problem using highly elongated orbits, ranging from tens of kilometers to 18,000 kilometers.

"We'll zip by the lunar surface for a brief time each orbit," explained Angelopoulos. "Most of the time we'll linger 18,000 kilometers away where we can continue our studies of the solar wind at a safe distance.

But over several years, even the sparse low-altitude measurements add up to a sizeable dataset."

ARTEMIS will work in tandem with current missions, such as NASA's Lunar Reconnaissance Orbiter, LADEE (Lunar Atmosphere and Dust Environment Explorer) and Grail (Gravity Recovery and Interior Laboratory), and Chang'e 2, a Chinese unmanned probe, to prepare the ground for increased robotic exploration of the moon by future U.S. missions, including the international lunar network.

Provided by University of California -- Berkeley