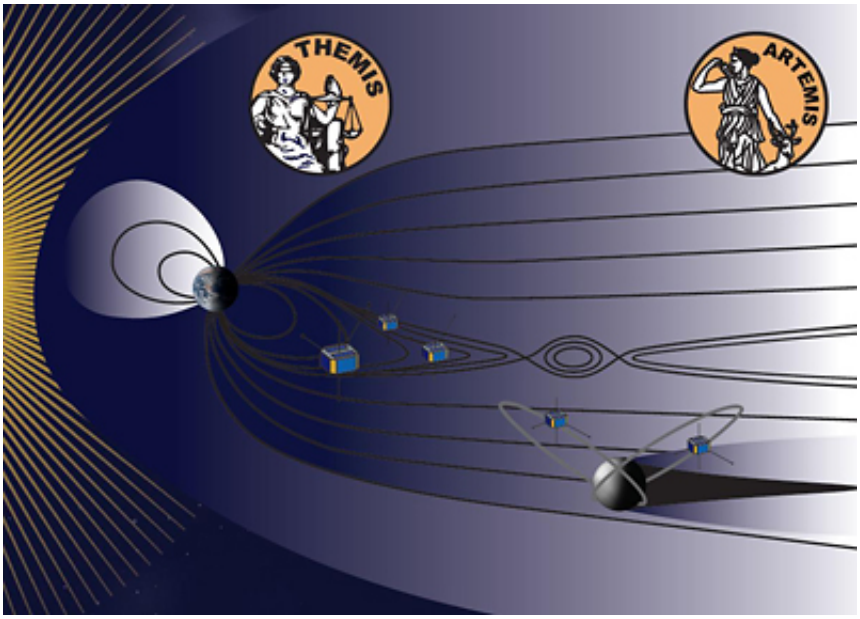
Twin ARTEMIS probes to study moon in 3-D

July 13 2011, By Robert Sanders



Pictorial representation of the ARTEMIS probes as they will orbit the moon beginning July 17. ARTEMIS P1 and P2 were the outermost two THEMIS probes before they began maneuvers on July 20, 2009, to swap an Earth orbit for a lunar orbit. Credit: UC Berkeley

(PhysOrg.com) -- On Sunday, July 17, the moon will acquire its second new companion in less than a month. That's when the second of two probes built by the University of California, Berkeley, and part of NASA's five-satellite THEMIS mission will drop into a permanent lunar orbit after a meandering, two-year journey from its original orbit around Earth.

The first of the two probes settled into a stable orbit around the moon's equator on June 27. If all goes well, the second probe will assume a similar lunar orbit, though in the opposite direction, sometime Sunday afternoon. The two spacecraft that comprise the ARTEMIS mission will immediately begin the first observations ever conducted by a pair of satellites of the lunar surface, its magnetic field and the surrounding magnetic environment.

"With two spacecraft orbiting in opposite directions, we can acquire a full 3-D view of the structure of the magnetic fields near the moon and on the lunar surface," said Vassilis Angelopoulos, principal investigator for the THEMIS and ARTEMIS missions and a professor of space physics at UCLA. "ARTEMIS will be doing totally new science, as well as reusing existing spacecraft to save a lot of taxpayer money."

"These are the most fully equipped spacecraft that have ever gone to the moon," added David Sibeck, THEMIS and ARTEMIS project scientist at the Goddard Space Flight Center (GSFC) in Maryland. "For the first time we're getting a unique, two-point perspective of the moon from two spacecraft, and that will be a major component of our overall lunar research program."

The transition into a lunar orbit will be handled by engineers at UC Berkeley's Space Sciences Laboratory (SSL), which serves as mission control both for THEMIS (Time History of Events and Macroscale Interactions during Substorms) and ARTEMIS (Acceleration, Reconnection, Turbulence, and Electrodynamics of the Moon's Interaction with the Sun).

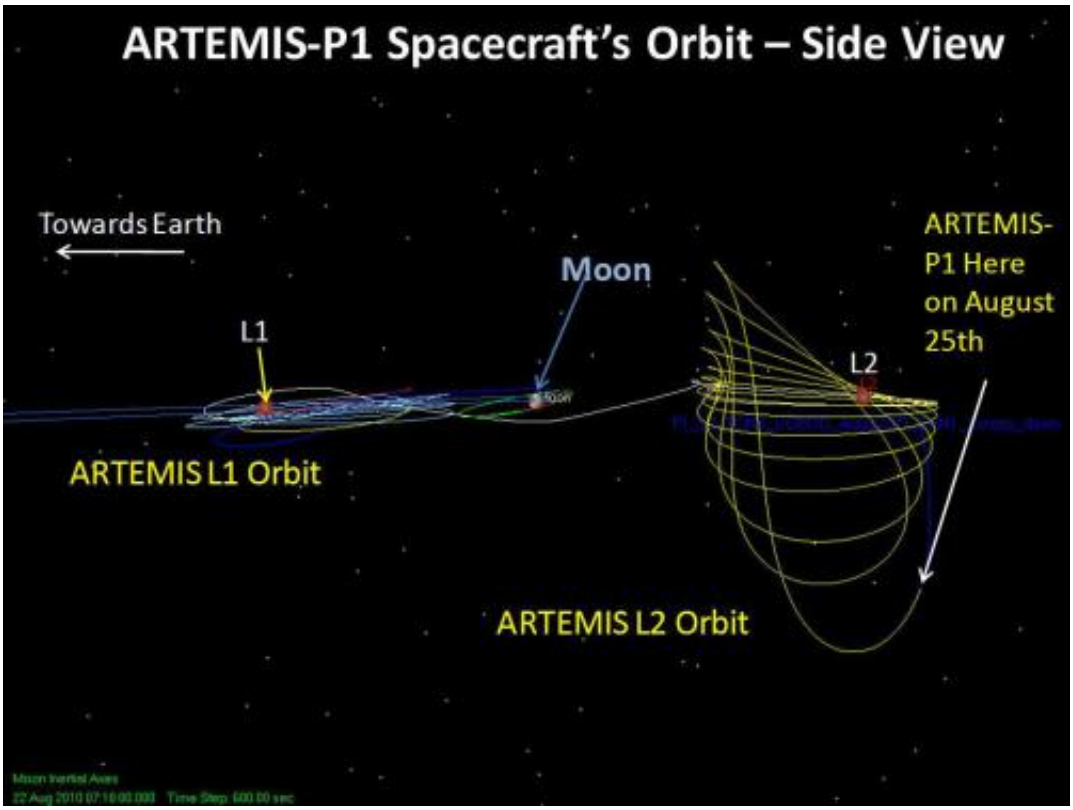
"We are on our way," said Manfred Bester, SSL director of operations. "We're committed."

What makes the auroras dance?

The five THEMIS satellites (or probes) were launched by NASA on Feb. 17, 2007 to explore how the sun's magnetic field and million-mile-per-hour solar wind interact with Earth's magnetic field on Earth's leeward side, opposite the sun. Within a year and a half, they had answered the mission's primary question: Where and how do substorms in the Earth's magnetosphere – which make the auroras at the north and south poles dance – originate?

The answer: the storms originate deep in the planet's shadow, about a third of the way to the moon, where magnetic field lines snap, reconnect and unleash a storm of energy that funnels to the poles and makes the atmosphere glow in reds and greens. Large storms can wreak havoc on satellites, power grids and communications systems.

Mission accomplished, the THEMIS team was eager to divert two of the probes to the moon to extend their magnetic field studies farther into space. One key reason was that the two probes most distant from Earth would soon die because, with too much time spent in Earth's shadow, their solar-powered batteries would discharge.



Side view of the ARTEMIS P1 probe's orbit in 2010 as it cruised around the two Earth-moon Lagrange points. In 2011 it maneuvered into a permanent orbit around the moon. Credit: NASA

To achieve this new mission, the UC Berkeley and Goddard teams, with the assistance of experts at the Jet Propulsion Laboratory in Pasadena, charted the 150 fuel-saving orbital maneuvers needed to boost the two THEMIS spacecraft from Earth's orbit into temporary orbits around the two Earth-moon Lagrange points, which are spots in space where the gravitational attraction from the moon and Earth are equal. That transfer took about 18 months, after which Goddard colleagues kept the two spacecraft in Lagrange-point orbits for several months before the first probe (P1) was transferred into lunar orbit last month.

"That was an engineering challenge; this is the first mission where we've

piloted into a lunar orbit spacecraft not designed to go there," said Daniel Cosgrove, the UC Berkeley engineer who controls the spacecrafts' trajectories. The probes' small thrusters, for example, only push down and sideways. The probes are also spinning, which makes maneuvering even more difficult.

Also, last year probe P1 lost a spherical sensor from the end of one of four long wires that protrude from the spacecraft to measure electrical fields in space. The probable cause was a micrometeorite that cut a 10-foot section off of the 82-foot wire and caused it to retract into its original spherical housing, sending the "little black sphere flying through the solar system," Bester said.

"All five spacecraft have been built by a very talented team with enormous attention to detail," he said, predicting that the ARTEMIS probes could survive for another 10 years, longer than the three remaining THEMIS probes, which repeatedly fly in and out of Earth's dangerous Van Allen radiation belt.

Lunar orbit

Once the second probe, P2, is in orbit, the two ARTEMIS satellites will graze the lunar surface once per orbit – approaching within a few tens of kilometers – in a belt ranging 20 degrees above and below the equator while recording electric and magnetic fields and ion concentrations.

"When the moon traverses the solar wind, the magnetic field embedded in the rocks near the surface interacts with the solar wind magnetic field, while the surface itself absorbs the solar wind particles, creating a cavity behind the moon," Angelopoulos said. "We can study these complex interactions to learn much about the moon as well as the solar wind itself from a unique two-point vantage that reveals for the first time 3-D structures and dynamics."

Sibeck noted that NASA's twin STEREO spacecraft, launched in 2006, already provide a 3-D perspective on the sun's large-scale magnetic fields. "THEMIS and ARTEMIS study the microscale processes, which we now know run the system," he said.

One goal of the ARTEMIS mission is to look for plasmoids, which are hot blobs of ionized gas or plasma.

"THEMIS found evidence that magnetic reconnection propels hot blobs of plasma both towards and away from the Earth, and we want to find out how big they are and how much energy they carry," Angelopoulos said. "Plasmoids could be tens of thousands of kilometers across."

"THEMIS found the cause and now ARTEMIS will study the consequences, which are likely massive and global," Sibeck said.

The spacecraft also will study the surface composition of the moon by recording the solar wind particles reflected or scattered from the surface and the ions sputtered out of the surface by the wind.

"These measurements can tell us about the properties of the surface, from which we can infer the formation and evolution of the surface over billions of years," Angelopoulos said.

The two ARTEMIS probes will join NASA's Lunar Reconnaissance Orbiter, which has been orbiting the moon since 2009 taking high-resolution photographs and looking for signs of water ice. In September, NASA is scheduled to launch two GRAIL (Gravity Recovery and Interior Laboratory) spacecraft to map the moon's gravitational field, and in 2013, the agency plans to launch LADEE (Lunar Atmosphere and Dust Environment Explorer) to characterize the lunar atmosphere and dust environment.

"ARTEMIS will provide context for the LADEE mission," Sibeck said.

Three other non-functioning satellites remain in orbit around the moon: two subsatellites of Japan's lunar orbiter, Kaguya, which was guided to a crash on the surface in 2009; and India's Chandrayaan-1, which lost communication with Earth that same year. China's second lunar orbiter, Chang'e 2, left the moon for interplanetary space on June 8.

Provided by University of California - Berkeley