Return to the moon

Orbiter to map lunar surface

BY STEPHEN CLARK
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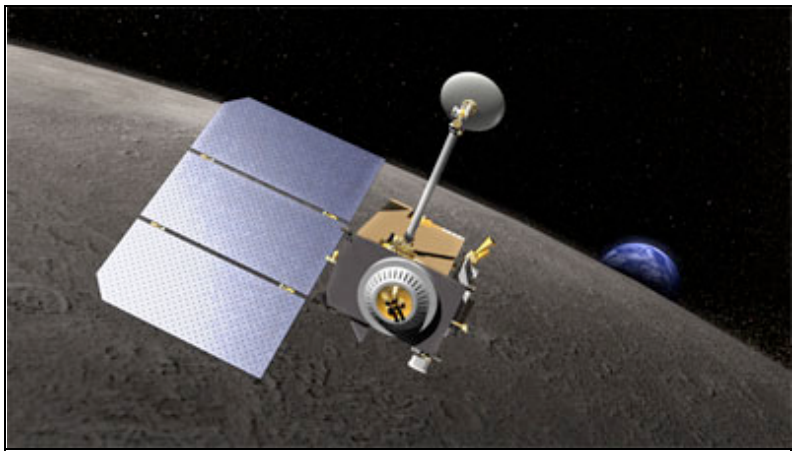
A robotic precursor of resuming human expeditions to the moon will likely be postponed by at least a few weeks from its October launch target, but NASA does not foresee any problems launching the lunar orbiter and high-speed impactor before the end of this year.



Artist's concept of LRO in orbit around the moon. Credit: NASA

NASA's Lunar Reconnaissance Orbiter, an observatory to map the lunar surface in search of potential landing sites for future human missions, is about two weeks behind schedule in meeting the craft's appointed launch date, said Craig Tooley, LRO project manager at the Goddard Space Flight Center.

"We know that there are things that await us as we pass through (testing) that will certainly take some unplanned time," Tooley said. "That's what experience has taught us on spacecraft here at Goddard."

Officials with the piggyback Lunar Crater Observation and Sensing Satellite mission, a secondary payload designed to take a suicidal plunge into one of the moon's impact crater, said their mission is about a month ahead of schedule.

Both missions are currently on the books for liftoff aboard an Atlas 5 rocket at about 1055 GMT (6:55 a.m. EDT) Oct. 28,

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the first day of a series of launch opportunities stretching through the end of 2008. But LRO's ambitious schedule of integration and testing will likely push launch into at least the middle of November, according to Tooley.

Tooley said project officials accepted a requirement to launch LRO before the end of this year, and the mission's ground processing plan leaves plenty of schedule margins to meet that time constraint.

"We have a whole series of launch opportunities that stretch from Oct. 28 through the end of the calendar year that we work with the Atlas launch vehicle. In all likelihood, as we get a little closer we'll probably pick one of those launch opportunities there in November or somewhere and say 'that's the one we're going to hit,'" Tooley said.

Five launch periods are available for LRO this year, beginning Oct. 28, Nov. 11, Nov. 24, Dec. 8 and Dec. 22. Each of the opportunities spans four days.

See our chart showing launch dates and times here.

"We are much more unconstrained than a planetary mission," Tooley said. "The moon is always there, and to establish the kind of orbit we're headed for and do a trajectory to the moon we can go almost every day."

Tooley said LRO's launch periods are derived from stringent science requirements to enter an orbit suitable for observing portions of the lunar poles that never see sunlight. Scientists believe such regions may harbor water ice.

LCROSS, a novel mission designed to search for the water ice deposits using a high-speed impact, will remain attached to the Atlas 5 rocket's Centaur upper stage after LRO is deployed.

Dan Andrews, LCROSS project manager at NASA's Ames Research Center, said the mission will be ready for flight when LRO completes its pre-launch preparations.

"We will launch on LRO's opportunity," Andrews said. "We have roughly a two-week cycle in which they could launch ... so our intention all along was we had to get to the finish line in time to support any of those."

Putting LRO together

Currently taking shape inside a clean room at the Goddard Space Flight Center in Maryland, the LRO spacecraft will weigh more than 4,000 pounds at the time of launch.

"The spacecraft bus is assembled," Tooley said. "All of the spacecraft avionics for the power, the command and data handling system which includes the computer, the propulsion system and such are all integrated and in the midst of testing."

Five of LRO's six science sensors are already attached to the spacecraft, and the mission's camera package will be delivered to Goddard next month from San Diego's Malin Space Science Systems.

"That's both our wide-angle camera and a pair of high-resolution cameras - really telescopes - that do all the imaging," Tooley said.

The camera system will be able to spot Apollo landing sites using its fine imaging instrument, which is able to resolve objects as small as 1.6 feet, or a half-meter across, from an orbital altitude of 31 miles.

LRO's suite of instruments is geared toward preparing for a new round of human exploration of the moon. Sensors mounted on the orbiter will evaluate the radiation hazards the lunar environment could pose to long-term human inhabitants, search for water ice in permanently shadowed regions of the moon, create a detailed terrain map to search for potential landing sites, and measure the moon's temperature across the lunar surface.

But before the craft can begin probing the moon, it must endure a long road to launch and voyage through space to enter lunar orbit.

Each instrument undergoes its own independent testing before and after being attached to the spacecraft.

"Everything that goes on the spacecraft gets tested before and after it goes on and then tested to make sure it's safe and functioning," Tooley said.

Once the orbiter is fully assembled, more tests are scheduled to ensure the probe is functioning properly.

"We have system-level functional tests happening still in ambient conditions in our clean room, where we put the whole spacecraft through its paces and actually simulate the mission and do functional tests with the whole thing as a system. Once we're satisfied with that, then it goes through a sequence of environmental tests, which really break into a set of structural mechanical tests, acoustic and vibration testing," Tooley said.

LRO will also face electromagnetic testing to make sure nothing interferes with the orbiter in space. The probe will enter a thermal vacuum chamber in mid-July to simulate environmental conditions in space during six weeks of thorough testing.

"The culmination is we put the satellite - the spacecraft - into the large thermal vacuum chamber here at Goddard, and we essentially simulate the mission as well as a whole sequence of functional tests while exposing it to the thermal environments that we expect to fly it through," Tooley said.

The spacecraft should be ready for shipment to Cape Canaveral in early September. After nearly two months of final preparations at the Astrotech facility in Titusville, Fla., LRO will be moved to the launch pad to be stacked atop the Atlas 5 rocket a few weeks before launch.

Hurdles on road to the moon

With barely three years to complete the mission's final design work, assembly and testing, Tooley said LRO's major challenge has been keeping on schedule to launch in 2008.

"The dominant problem that we always have is the quest to hold this schedule without compromising our reliability," Tooley said.

The science payload was selected in late 2004 from a list of flight-proven equipment already aboard NASA's New Horizons, Mars Reconnaissance Orbiter, Mars Odyssey, and Polar missions.

"We knew also that the instruments would need to be built even quicker than the whole mission because we needed them to get done and show up. They were solicited such that we would get instruments that leveraged other planetary instrument heritage, not invent the next-generation planetary instrument," Tooley said.

In addition to other demonstrated components, LRO will use propellant tanks from NASA's Tracking and Data Relay Satellite fleet.

"In general, most of the problems or unexpected work that we've had to do often revolved around actually adapting the instruments that had been used on other planetary missions, or even some of the spacecraft design heritage that we had, to the lunar mission - particularly the thermal environment of the moon," Tooley said.

LRO's orbit will present more difficult thermal challenges

than Earth-orbiting satellites, Mars orbiters, and some other planetary missions.

"The moon is just a pretty harsh mistress for us," Tooley said. "That gave us some surprises in the extent with which things we thought were heritage had to be re-engineered to do this mission."

Project officials received final authority to proceed with the mission in May 2006.

"We've come from the day we were confirmed at NASA, which is really when got the green light, to now only a few weeks shy of the original launch date that was conceived of before we had even started. I think we've done pretty well," Tooley said.

LRO's growing launch weight forced NASA to change the mission from a Delta 2 rocket to the larger Atlas 5 in 2006.

"We did redesign the spacecraft fairly substantially only about a month before our preliminary design review, when our launch vehicle had to change from a Delta rocket to an EELV - an Atlas in the end. That was a major perturbation to this rapid design cycle and we had to reconfigure the entire spacecraft for a different launch vehicle and some other things," Tooley said.

"The development schedule for the LRO Project is very aggressive - only 33 months from inception to launch. Many challenges remain in the schedule, and the LRO Project Office at Goddard has been very proactive in addressing these challenges," said Stephanie Schierholz, NASA spokesperson, in a response to written questions.

The Atlas 5's launch time and flight plan will be determined by what day launch occurs. All launch opportunities will come with a morning blastoff, and the time of trans-lunar injection, the rocket firing to place LRO on a path toward the moon, will vary from about 40 minutes to more than one-and-a-half hours after liftoff.

LRO will be cast free from the Centaur upper stage a few minutes after the rocket's RL10 engine propels the probe on a course toward lunar orbit. The probe will conduct a mid-course correction burn and a maneuver to insert the spacecraft into a preliminary orbit about the moon.

"Four days from launch, we're orbiting the moon," Tooley said. "In a couple of months, we do commissioning in a slightly different orbit than our final orbit to save some fuel, then we lower down and commence with the one-year

mission."

Officials expect LRO to be declared operational by next January if launch occurs before the end of November.

The mission is slated to last about one year, with the potential of an extension if the orbiter is still functioning well.

LRO will join an international fleet of probes studying the moon. Japan's Kaguya spacecraft and China's Chang'e 1 orbiter arrived at the moon last fall, and India will soon join the offensive with the launch of its Chandrayaan 1 probe in July.

"What LRO does is LRO does the measurements and makes the maps that are specifically the maps that are needed to support and enable the exploration initiative - the human return to the moon. The choices of our resolutions, the way we're going to do our targeting, (and) the maps we're going to make. We fly lower than the rest of those missions in order to enhance our resolution. So LRO is going to answer the data needs of the exploration initiative," Tooley said.

LRO is the first operational step of NASA's exploration vision announced by President Bush in 2004. Bush committed NASA to beginning renewed robotic exploration of the moon by 2008, a goal that later morphed into the LRO mission.

"We take the commitment very seriously to take that first step and start doing this essentially as we committed to. We want to do it for the budget and in the timeframe that NASA committed to," Tooley said.

LRO's total mission cost is approximately $491 million, including the spacecraft, launch vehicle, science instruments, ground network, and operations expenses.

"We're within budget right now," Tooley said. "The price we started with is also the price we're at."

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