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NASA's smashing way of answering a watery question

BY JUSTIN RAY
SPACEFLIGHT NOW
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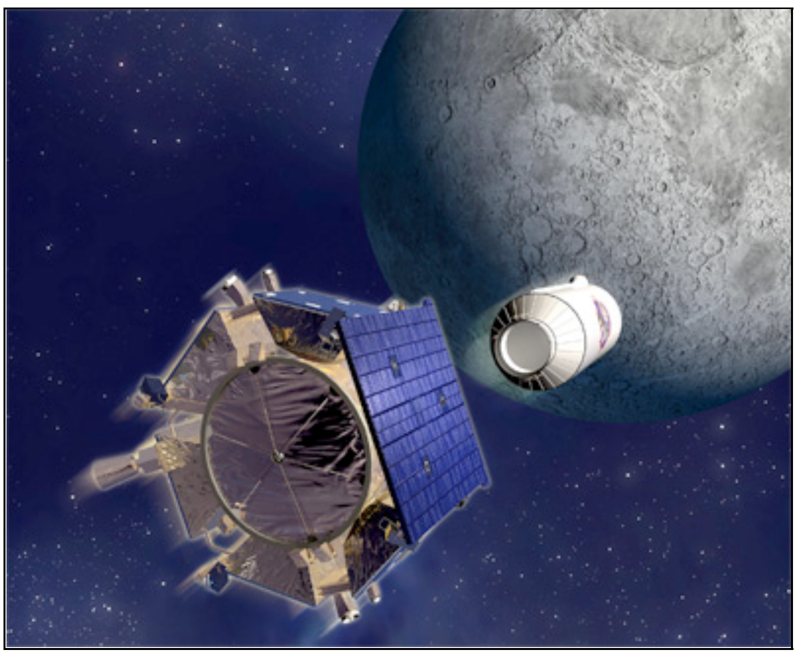
Are polar craters on the Moon, eternally dark places where sunlight hasn't been seen for billions of years, harboring natural reservoirs of water ice that could be farmed by future colonists? That's a question that NASA's audacious lunar impactor experiment plans to answer.

Hitching a ride using excess room aboard the Atlas 5 rocket, the relatively inexpensive Lunar Crater Observation and Sensing Satellite was developed on the fast track using ingenuity and off-the-shelf parts.



An artist's concept shows the LCROSS spacecraft behind the Centaur during final approach to impact. Credit: Northrop Grumman

The $79 million mission will crash the discarded Centaur upper stage into a permanently shadowed crater at the Moon's south pole, blasting a giant cloud of lunar debris up into the daylight for instruments to probe for signs of water.

"A very exciting mission culminating in a real crescendo event," says Dan Andrews, LCROSS project manager.

The Mission

Rocket: Atlas 5 (AV-020)
Payload: LRO/LCROSS
Date: June 18, 2009
Times: 5:12, 5:22 and 5:32 p.m. EDT
Site: Complex 41, Cape Canaveral, Florida

- Mission Status Center
- Archived video coverage
- High Definition video
- Our launch preview
- LRO preview story
- LCROSS preview story
- LRO quick facts
- LCROSS quick facts
- Launch events timeline
- Ground track map
- Atlas archive

Two previous Moon orbiters launched in the 1990's -- the U.S. military's Clementine and NASA's Lunar Prospector -- detected hydrogen at the poles. But the discovery left open the question of whether the hydrogen was water.

"Both indicated a curious abundance of hydrogen in these cold traps in permanently shadowed craters in the polar regions of the Moon...LCROSS is specifically purposed to go and find out of that hydrogen could be an indication of water ice," Andrews said.

"How is it possible on an airless body like the Moon you could possibly have water ice exist for any amount of time? This gets to the feature ...of permanently shadowed craters. There's extreme topography on Moon and at the poles the sun never comes more than a degree-and-a-half or so above the horizon. So the crater rims can constantly shadow the crater floors," said Tony Colaprete, LCROSS project scientist.

"They could have been permanently shadowed for a billion, two billion, maybe more, years. And by cold, I mean cold - Minus 200 degrees C."

If ice exists in large quantities on the Moon, the natural resource could be harvested by astronauts for the production of drinking water, breathable air and rocket fuel. Living off the land would save crews from trucking all of their supplies from Earth in futuristic exploration plans.

"The benefit of having water ice there is self-evident. The availability of water right there on the Moon, availability of producing oxygen, oxidizer for rocket fuel for other missions, it's very, very interesting if water ice is indeed there," Andrews said.

The LCROSS project was born from a NASA competition to create a co-passenger for the Lunar Reconnaissance Orbiter aboard the Atlas 5 rocket. When LRO was switched from initial plans to fly atop a Delta 2 rocket to the larger Atlas, extra payload mass was available for a secondary payload. The Ames Research Center-led impactor mission was selected.

At the core of LCROSS in a ring-shaped structure originally built to hold multiple small satellites for launch into space on a single rocket. The hardware was used by the Air Force to deploy a flock of four small test spacecraft in 2007.

But the LCROSS engineers took the ring, given its ideal design that would allow instruments, electronics and a solar panel to be plugged into the adapter slots, and turned it into a real satellite that's known as the mission's shepherding spacecraft. The completed craft will weigh 1,665 pounds at launch, including 675 pounds of maneuvering fuel.

About four hours after launch, the then-depleted Centaur upper stage will relinquish control to the still-attached LCROSS vehicle. The shepherding spacecraft assumes the role as an orbital tugboat for the 5,200-pound rocket motor during several highly elliptical orbits around the Earth in preparation for impact on October 9.

"The Centaur upper stage rocket has never been used in this configuration before. The job of the Centaur is to get a heavy load out of Earth's gravity field and not to drag around space," said Kimberly Ennico, LCROSS payload scientist. "In fact, after the Centaur hands off control of the spacecraft to us it's considered just dead weight."

The Centaur rocket for the LCROSS mission is seen here during pre-launch assembly at Cape Canaveral. Credit: NASA

Throughout the four months of looping around the planet, the Centaur can vent away the residual traces of its liquid hydrogen and liquid oxygen rocket fuels. Getting rid of the cryogenics is crucial to prevent unwanted contamination of the experiment specifically looking for water on the Moon.

No later than a month prior to impact, mission officials will decide which crater at the lunar south pole LCROSS should target. Scientists hope the Lunar Reconnaissance Orbiter will supply late-breaking information about candidate craters soon after that craft enters its science mode.

"At launch, we know which pole. It's Impact Minus-30 days that we have to decide exactly where we're hitting," Ennico said.

"Impact Minus-30, we have to know where we are going because we have to do all these clever burns because the propulsion system is cowboy-esque."

The satellite, which was put together by Northrop Grumman, carries five cameras for color, thermal and near-infrared images to study the debris plume, a photometer that takes a thousand measurements per second to see the flash of impact and three spectrometers that will be the workhorses in identifying the composition of the ejecta.

"Those are the LCROSS instruments. They're going to be very up close and personal, never further than 600 kilometers away and closing fast," said Colaprete.

Some 9 hours and 40 minutes before impact, the shepherding spacecraft releases the Centaur for the final plunge. LCROSS simply lets go and allows the lunar gravity to pull the rocket, the size of a sports utility vehicle, into the Moon.

"We're going take this SUV and impact it into the Moon at about 5,600 mph," Ennico said.

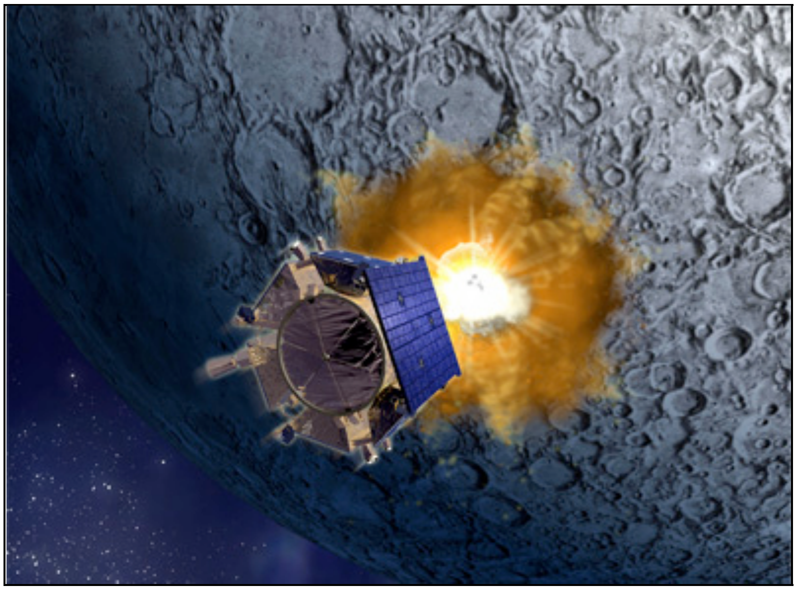
The shepherding spacecraft, now flying on its own, performs a 180-degree pirouette to point the science instruments in the proper direction and also executes a braking maneuver in order to create a four-minute gap between itself and the Centaur for viewing the impact.

Large observatories in Hawaii and the continental U.S., plus the Lunar Reconnaissance Orbiter and even the Hubble Space Telescope will join enthusiastic amateur astronomers planning to witness the cosmic crash.

"It will be accessible by amateurs with a ground-based telescope of about 8 to 12 inches on a dark site," Ennico said. Exact viewing conditions will depend on the actual LCROSS launch date.

Five orbits of Hubble observing time using the newly repaired STIS instrument to look at the ejecta, plus possible imaging of the impact using the new WFC3 camera is planned, Ennico said.

"The impact sounds spectacular, and it will be. But you have to consider impacts of this size hit the Moon three or four times a month, essentially once a week. What's unique about the LCROSS impact is we know exactly where and when, so we can actually get and coordinate all of these eyes to look at it," said Tony Colaprete, LCROSS project scientist.



An artist's concept shows the LCROSS spacecraft behind the Centaur during final approach to impact. Credit: Northrop Grumman

Diving at angle of nearly 80 degrees, the Centaur will smack the Moon and carve a crater about 20 meters (66 feet) in diameter.

"We want this to belly-flop on a crater. We want to excavate only the top one meter of the regolith," Ennico said.

"We are hoping to excavate about 350 metric tons of material up above an altitude that's greater than 10 kilometers. Over 50 percent of it will just go plop. It'll just be a blanket. We can only see any of the material that gets above the crater rim."

Digging any deeper into the Moon isn't something the LCROSS scientists want to do.

"We know from Lunar Prospector that there's hydrogen within the top meter. The neutrons that are detected can only actually be emitted or escape from approximately the top 70 or 100 centimeters of regolith. So from the get-go we know there is at least something bearing hydrogen in the top meter of lunar regolith. There could potentially be more below that, there could be potentially horizons of hydrogen-rich, hydrogen-poor and so on. So this is one of the things that LCROSS will address," Colaprete said.

At the moment of impact, the LCROSS satellite will be about 600 kilometers (373 miles) behind the Centaur. It instruments will be streaming all of the measurements and pictures directly back to Earth in real-time. There's no use storing any data onboard. The shepherding spacecraft will meet its own demise in just four minutes, forming a crater 14 meters (46 feet) in diameter.

Picking the right lunar crater to target involves a site that has signs of hydrogen accumulation, a crater large enough to accurately hit and rims not too high that would block out the sunlight from illuminating the ejecta plume.

"Because we have to belly-flop, kick ejecta up into the sunlight and we have measure it within four minutes, we gotta get above a crater rim. So the nominal case is a two-kilometer rim height," Ennico said.

"Most of the mass will not exceed about six to seven kilometers above the surface and it will expand outward like an upside down lamp shade, finishing at about 50 kilometers across when it's fully settled out," Colaprete said.

It should take between just two and five seconds for the ejecta to reach sunrise, unveiling the potential water ice for the experiment to begin.

"The peak observing time exists probably from about 30 seconds to 100 seconds after the impact. That's when things are the brightest, we're filling our apertures and so on. We're about 500 to 300 kilometers away," Colaprete said.

"The actual event will be done in four minutes, meaning the ejecta, the physical material that comes up will be all but settled out in four minutes. It's just like any other natural impact of the Moon, it will not damage the Moon in any way," Colaprete continued.

"We've actually spaced the spacecraft observation point, in part, to address hazards to our spacecraft. For example, we didn't want to observe it from just a two-minute separation because that would have been a little too personal. But also we considered things like filling our instrument apertures properly. So that's how we came up with this four-minute separation."

"If we find there's actually water in this crater, we're going to then understand the permanently shadowed, cryogenically cooled craters which there are numerous ones," said Craig Tooley, the Lunar Reconnaissance Orbiter project manager.

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