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NASA Successfully Launches LRO/LCROSS for Return to the Moon

June 18th, 2009 by Chris Gebhardt

An Atlas V rocket carrying NASA's Lunar Reconnaissance Orbiter (LRO) and sister payload Lunar CRater Observation and Sensing Satellite (LCROSS) has launched from complex 41 at Cape Canaveral on Thursday evening. Both its payload passengers were successfully sent on their journey to the moon.

Atlas V/Launch Overview:

The veteran Atlas V rocket – making its 19th lunar flight – that will loft the LRO/LCROSS dual payload to the moon will fly in the 401 configuration with a four-meter fairing, no solid rocket boosters and a single-engine Centaur upper stage.

Given the precise nature of the LRO/LCROSS missions, the launch window is four days in duration – lasting from June 17 to June 20.

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For its opening launch attempt on June 18, the Atlas team will have three opportunities to launch the pair of lunar satellites on their mission. The first attempt comes at 5:12pm EDT, with subsequent attempts available at 5:22pm and 5:32pm. Due to weather, controllers opted for the final available attempt.

For launch day, the 45th Weather Squadron of the Air Force is predicting a 40 percent chance of violating weather constraints – with the main concerns being anvil clouds, cumulus clouds, and rain within 10nm of the launch pad/flight path.

The weather forecast, at this time, remains essentially unchanged in the event of a 24-hour or 48-hour scrub turnaround.

In the event of a launch on June 19, the three launch times are: 6:41pm, 6:51pm, and 7:01pm. Similarly, if launch should occur on June 20, the launch times are: 8:08 pm, 8:18 pm. and 8:28 pm.

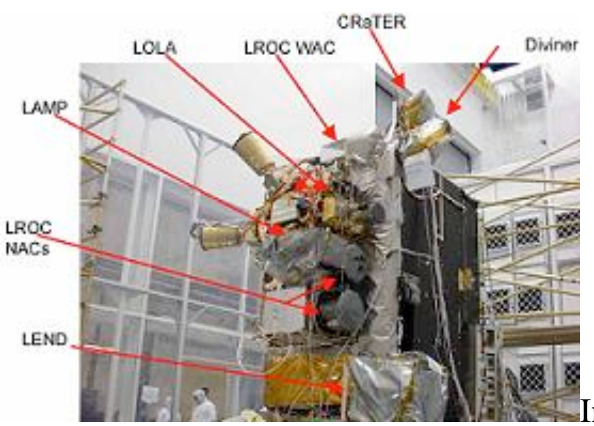
If, for some reason, the Atlas team is not able to achieve launch by June 20, the next four day launch window starts June 30.

LRO:

The primary satellite for this mission is the Lunar Reconnaissance Orbiter (LRO).

LRO, which sits on top of the LCROSS experiment for launch, will be released from its LCROSS companion after it is placed on its lunar-transfer trajectory to enter lunar orbit approximately four days after launch from Cape Canaveral.

LRO is expected to have a two month commissioning period prior to beginning its one year primary science mission.



In all, the LRO spacecraft has six primary instruments: CRater, DLRE (Diviner Lunar Radiometer Experiment), LAMP, LEND (responsible for acquiring high-resolution neutron datasets), LOLA, and LROC.

In particular, one of LRO's six primary instruments is the DLRE – the first instrument to "systematically map the global thermal state of the Moon and its diurnal and seasonal variability."

During LRO's primary one year science mission, the DLRE will be capable of locating resources critical to humanity's return to the moon – currently scheduled for the end of the next decade.

DLRE will be responsible for creating detailed, global maps of the lunar surface temperature over the lunar day and year, assessing the stability of potential polar ice deposits, mapping compositional variations in the lunar surface, and allowing lunar scientists to identify potential hazards on the lunar surface such as roughness of the terrain and rock concentration.

As a side note, the DLRE will also be able to detect the lunar rover tracks and the six descent stages left behind from the various Apollo missions in the late 1960's and early 1970's.

Overall, the main science goals for DLRE – identified by the science team and NASA – are: "Mapping global day/night surface temperatures, characterizing thermal environments for habitability, determining rock abundance at potential landing sites, identifying polar cold traps and potential polar ice deposits, and mapping variations in silicate mineralogy."

To accomplish these objectives, DLRE will collect measurements on reflected solar and emitted infrared radiation along nine spectral channels with wavelengths between 0.3 and 400 microns.

Among these nine channels are "two solar reflectance channels, three mineralogy channels, and four thermal channels."

These particular channels are distributed between two identical, bore-sighted telescopes – telescopes A and B. These telescopes are 3-mirror, off-axis, focal length 1.7 telescopes with 4-centimeter apertures.

Telescope A will monitor channels between 0.35 and 23 microns, where Telescope B will monitor channels between 25 and 400 microns.

The DLRE will be positioned primarily in a nadir orientation. It is mounted on the nadir panel of the LRO which will allow the instrument continuous views of the lunar surface as LRO's other instruments conduct their observations or — thanks to two actuators which allow 270 degrees of motion – a view of space.

One of the reasons this instrument is so important to the LRO team and NASA is its ability to increase our knowledge of the lunar seasons and lunar thermal environments.

As the DLRE fact sheet indicates, the moon's surface thermal environment is among the most extreme of the planetary bodies in our solar system – representing a unique challenge to future human settlements and robotic mission to our natural satellite as all spacecraft and housing units will have to be able to withstand the drastic thermal changes present on the moon.

In particular, there are three thermal areas on the moon: daytime, nighttime, and polar.

Specifically, the moon's daytime thermal environment is controlled by "the flux of solar radiation" – allowing temperatures to reach as high as 260 degrees F/127 degrees C. In contrast, the 14-day lunar night cycle sees temperatures of -179 degrees F/-173 degrees C.

However, the lunar polar regions' thermal characteristics are more complex. Essentially, the topography and lunar seasons play a large role in determining the polar regions' thermal properties.

While parts of the polar regions receive very little direct illumination from the sun, others receive permanent illumination or no illumination at all. In the regions that receive very little sunlight, it is currently thought that the daily temperatures range from -297 degrees F/-182 degrees C to -387 F/-232 C – possibly even lower.

By using the DLRE and LEND instruments, NASA and lunar scientists will be able to correlate hydrogen abundance with cold-trap surface and subsurface temperatures.

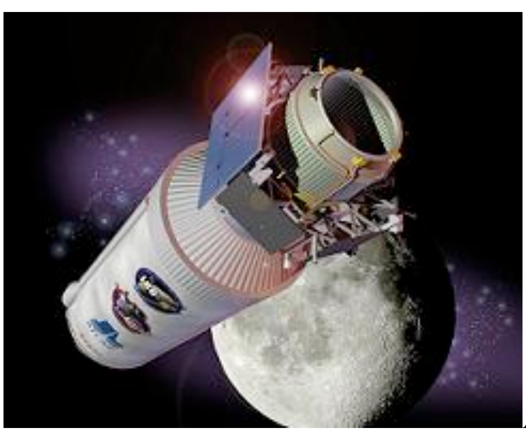
To this end, high levels of hydrogen would lend evidence to the presence of cold-trapped water ice – an important find for the future of human exploration of the solar system.

LCROSS:

NASA's Lunar CRater Observation and Sensing Satellite (LCROSS) was selected in April 2006 as a "low-cost, fast track companion mission for LRO."

Designed to answer the question "Does water exist in a permanently shadowed lunar crater," the LCROSS experiment will utilize a "shepherding spacecraft" packed with instrumentation and the Atlas V's Centaur upper stage to complete its mission objectives of smashing into a permanently shadowed crater on the moon's south pole and examining the ejecta plume for traces of water and other minerals/materials that might be useful to future human settlements on our closet cosmic neighbor.

To accomplish these objectives, the LCROSS part of the mission will separate from the LRO satellite shortly after the combined spacecraft is put into it lunar-transfer trajectory.



After separation from LRO, a guided blow down – blowing cold propellants through the Centaur's engine, without igniting the engine, to get a few hundred pounds of thrust – will be performed to place LCROSS on course of its elongated Earth orbit and eventual impact with south pole lunar crater.

After that, the Centaur upper-stage with the attached shepherding spacecraft will be put into a flat-spin to deplete propellants and inert the centaur upper-stage so no contaminants are introduced to the lunar crater during the Centaur impact roughly 100-days later in early October (9th – 11th depending on launch day).

After a nearly 100-day coasting phase to properly align the combined satellite and impactor with its final crater target, the LCROSS satellite will separate from the Centaur upper stage.

After firing its thrusters to slightly lower its velocity, the LCROSS shepherding satellite will trail about four minutes behind the Centaur upper stage, flying through the ejecta cloud created by the Centaur's impact with the lunar surface.

After flying through the debris cloud – collecting invaluable scientific data and transmitting that data real-time to Earth – the LCROSS shepherding satellite will also impact the lunar surface, creating a second debris cloud.

Onboard the LCROSS shepherding spacecraft will be a host of scientific instruments including two near-infrared spectrometers, a visible light spectrometer, two mid-infrared cameras, two near-infrared cameras, a visible camera, and a visible radiometer.

These instruments were selected to "provide mission scientists with multiple complimentary views of the debris plume created by the Centaur impact," notes a NASA fact sheet about the mission.

Following the Centaur's impact in a predetermine crater, the ejecta cloud will rise above the surface of the crater's rim – thereby exposing the ejecta to sunlight. Once this occurs, any water, hydrocarbons, or organic materials will vaporize or sublimate and break down into their basic components.

It is these components at the LCROSS shepherding spacecraft will monitor and analyze as it passes through the ejecta cloud before its impact to the lunar surface.

The near-infrared and mid-infrared cameras will help determine the total amount and distribution of water in the debris plume while the visible radiometer will monitor the flash created by the Centaur's impact on the surface.

Based on a launch during the June 18th - 20th window, both debris plumes from Centaur and LCROSS' shepherding spacecraft are expected to be visible from Earth-based telescopes of 10- to 12 inches and larger across the continental U.S.

The plumes are also expected to be visible from space-based telescopes as well – including the recently upgrading Hubble Space Telescope.

The LCROSS mission is expected to expedite our search for water ice on the moon using information gathered from the Clementine and Lunar Prospector missions in 1994 and 1998, respectively.

Together, the LRO/LCROSS missions – which are components of the Lunar Precursor Robotic Program from the Marshall Spaceflight Center in Huntsville, AL – will help map the moon's surface and pave the way for future robotic and human missions to the moon in the years to come.

As Todd May stated in the LRO/LCROSS pre-launch briefing on Monday, "LRO and LCROSS will give us the information about the moon that we already have about Mars."

Tags: Atlas V, LRO

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