National Aeronautics and Space Administration

NASAfacts

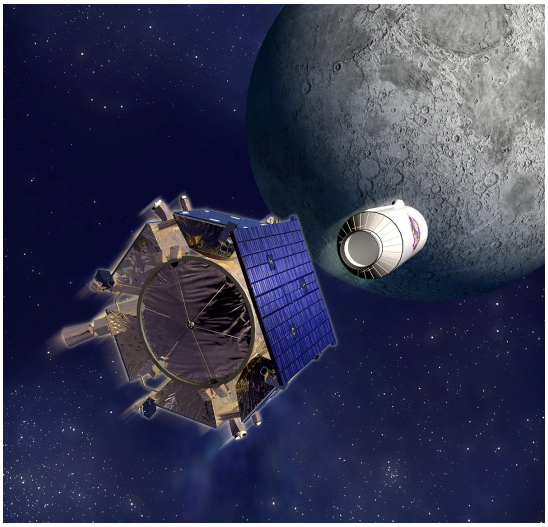
Space Technology
Game Changing Development
In Situ Resource Utilization
Locating and Utilizing Resources at Our Exploration Destinations

Every space mission to date, both human and robotic, has used propellants and consumables brought from Earth. When those resources are exhausted, the mission must end or be resupplied from Earth, which can be an expensive proposition. Because of this, Apollo missions to the Moon could only sustain a stay of 3 days on the lunar surface despite being launched by the largest rocket ever built by mankind. A paradigm shift is required if we are ever going to have a sustained human presence in space beyond low-Earth orbit.

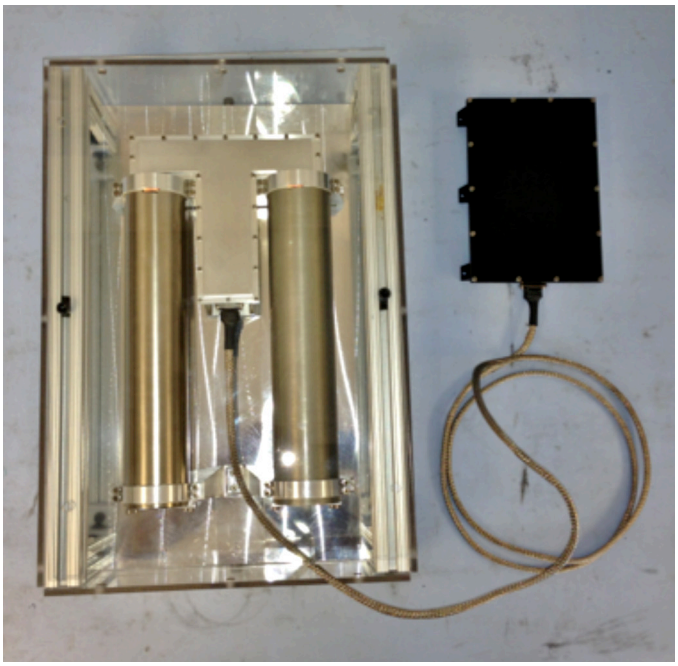
In Situ Resource Utilization (ISRU) is a truly game changing approach to space exploration. Every destination has a wealth of resources that can be harvested and used to support exploration missions. For example, Mars has an atmosphere that can be processed to produce oxygen to use for life support or as an oxidizer for a rocket engine. If water is found in the near subsurface of Mars, it could be processed and used by astronauts to drink. Hydrogen from the water —combined with the carbon dioxide found in the atmosphere—would produce methane, an excellent rocket fuel. Even asteroids and the Moon have resources that can be processed for needed mission consumables.

Once the technologies needed to produce these consumables are created, it will change the way NASA explores space. For example, for a human Mars mission, NASA could launch the Mars ascent stage with its tanks empty and fill them with propellant produced on Mars. While that may not seem like a big change, it makes a huge difference in the size of launch vehicle needed. Studies have shown that simply making the ascent propellant on the surface of Mars can reduce the initial size of the launch vehicle needed for the mission by 3.5 to 5 times.

NASA's Space Technology Mission Directorate (STMD) is taking steps to turn this vision into a reality. NASA's Lunar Crater Observation and Sensing Satellite (LCROSS) mission in 2009 discovered that there is water ice located in cold traps at the poles of the Moon. Before establishing a "mining" operation to harvest and utilize that water ice, it would need to prospect for and analyze the "ore" body, similar to the prospecting activities that take place here on Earth before establishing a mine. The ISRU project within STMD is developing the instruments that will be needed for



Artist's rendering of the LCROSS spacecraft and Centaur separation as they approach impact with the lunar south pole on October 9, 2009.

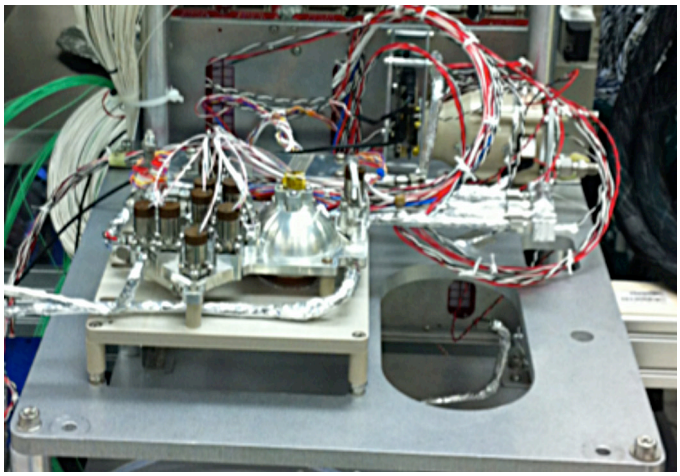


Neutron spectrometer for subsurface water ice detection.

a prospecting mission to the Moon, which is planned for launch before the end of this decade.

To find the water in the subsurface of the Moon and other planetary bodies, a team led by NASA's Ames Research Center is developing an advanced neutron spectrometer (NS). Mounted on the front of a rover, the NS will be able to sense hydrogen atoms up to a meter beneath the surface, helping to create maps of water ice in the lunar subsurface. This information will tell engineers where to dig or drill to find water ice located beneath the dry upper layer of the Moon's regolith. The NS prototype was completed in the summer of 2013. It is now undergoing performance testing and will undergo field trials in the coming months. The instrument will transition to NASA's Advanced Exploration Systems Program for inclusion in the instrument suite on the Resource Prospector Mission.

After a suspected source of subsurface resources has been identified, a sample will be collected using a coring drill. That sample will be heated to evolve the volatile gasses frozen in the sample. NASA's Kennedy Space Center will lead the development of a Lunar Advanced Volatiles Analysis system that will identify the gases as they are released. The system uses a rapid sampling



Lunar Advanced Volatiles Analysis prototype.

mass spectrometer to identify the atomic mass of each gas evolved. This mass spectrometer has a sampling speed that is 10 times faster than any similar device flown. This speed will allow it to be coupled with a gas chromatograph, which will be used to quickly distinguish between compounds that have matching atomic masses. This rapid sample analysis is required for lunar polar missions because there is only 5 to 7 days of sunlight available to conduct the prospecting mission. This rapid analysis capability can be applied to many different space missions and will increase the scientific return over what had previously been achievable.

The neutron spectrometer and rapid sampling mass spectrometer both have applicability to water and volatile gas prospecting missions to Mars and asteroids. Once we've characterized the resource viability for consumable production it will open the path for pilot plant operations and ultimately an ISRU-based exploration architecture for the human exploration of space.

The Game Changing Development (GCD) Program investigates ideas and approaches that could solve significant technological problems and revolutionize future space endeavors. GCD projects develop technologies through component and subsystem testing on Earth to prepare them for future use in space. GCD is part of NASA's Space Technology Mission Directorate.

For more information about GCD, please visit http://gameon.nasa.gov/

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