

## Space systems

Space systems activity in 2005 has covered many exciting and diverse areas of science and engineering. It was just under two years ago, on January 14, 2004, that President Bush announced the Vision for Space Exploration, which focused on returning to the Moon and continuing to Mars, along with plans for the shuttle's Return to Flight and for completing the International Space Station (ISS).



*Succeeding the space shuttle will be new vehicles such as NASA's Crew Exploration Vehicle and Lunar Surface Access Module. Image courtesy of NASA/John Frassanito and Associates.*

### Vision for Space Exploration

This September, NASA Administrator Michael Griffin laid out the details that resulted from the agency's Exploration Systems Architecture Study. The launch vehicles that replace the shuttle will be focused designs that build off current and derived space shuttle hardware (such as solid rocket motors, the orbiter liquid oxygen/hydrogen main engine, and the external tank). A new Crew Exploration Vehicle (CEV) will carry four to six people from LEO up to the space station and to the Moon and Mars. With hardware that is less complex than the shuttle's, these new vehicles will be safer, relying on proven technologies such as a ballistic capsule for crew transport.

The CEV and Cargo Launch Vehicle (heavy-lift version) will both need liquid oxygen/hydrogen upper stages to get the mass of the CEV up to the ISS or to send a CEV and Lunar Surface Access Module on their way into cislunar space. Both will most likely require clusters of current or derivative liquid oxygen/hydrogen engines, similar to the Pratt & Whitney Rocketdyne RL10 used on Delta IV and Atlas V launch

systems and the space shuttle main engine, or a newer version of the J-2S which was used on the Saturn V for Apollo missions. This new "shuttle-derived" architecture will provide transportation to the ISS and carry a crew of four to return to the Moon by 2020 for around \$100 billion. To keep the cost in perspective, Americans spend about \$100 billion per year on pizza, alcoholic beverages, and cosmetics.

### Planetary studies

Several important science missions were successful this summer. On July 4, the Deep Impact spacecraft released an 820-lb, washing machine-size "impactor" that intentionally slammed into the surface of comet Tempel 1 at about 2 a.m. EDT. Tempel 1 was approximately 268 million miles from Earth at the time of the "smash-landing." The purpose of the mission was to gather data about the material below the surface of the comet to gain a better understanding of how the solar system was formed. The University of Maryland was responsible for the science and the overall mission, Ball Aerospace and Technologies built the spacecraft, and JPL handled project management.

Making the Vision for Space Exploration a reality will require robotic as well as human spaceflight. To support the Vision's Mars exploration roadmap, NASA launched the Mars Reconnaissance Orbiter (MRO) from Cape Canaveral AFS on August 12. This was NASA's first use of the Atlas V rocket. MRO is healthy, all systems and instruments have been checked out, and all are performing as designed. MRO will arrive at Mars in March 2006 and is expected to begin the primary science phase in November after aerobraking into a parking orbit. The orbiter will conduct a 25-month mission to study surface composition and probe the subsurface for evidence of water. Following the science phase, MRO will serve as a communications relay for future missions, including the Phoenix lander. JPL manages the mission for NASA; Lockheed Martin built the spacecraft and launch vehicle.

Much deeper into the solar system, in the vicinity of Saturn, the Cassini spacecraft released the Huygens probe on December 25, 2004, and the first images from its instruments arrived in January 2005. Although NASA had responsibility for the Cassini spacecraft, once the probe passed through the interface altitude of around 1,270 km, ESA took over. The images from Huygens' instruments were made public in March, and astonishing features such as shorelines and possible lakes of liquid methane were revealed. In June, further study of Huygens' images may

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have revealed a never-before-seen body of liquid hydrocarbons on the surface of Titan, although the evidence is far from conclusive.

### Plug-and-play

In the evolving area of military space, the design and operation of responsive launch vehicles and spacecraft saw several advancements this year. Quick integration and launch of spacecraft have been identified as a means of achieving responsive space; and a key element of rapid integration will be the application of enhanced plug-and-play standards to spacecraft components. Application of plug-and-play will result in a paradigm shift with respect to traditional spacecraft development methodologies.

Microcosm, in conjunction with HRP Systems, under a Phase-II SBIR contract from AFRL/VSSE, has developed a rapid prototype implementation of plug-and-play components focused on a guidance, navigation, and control application. The objective of the SBIR was to create a self-configuring network based on the plugged-in, available components.

AFRL is leading a national effort to develop a modular, self-organizing plug-and-play electronics approach, or SPA. This SPA effort builds on a decade of research in advanced packaging, multifunctional structures, and reconfigurable architectures. It also exploits popular commercial and space standards such as USB (Universal Serial Bus) and Spacewire.

Through AIAA, a committee of standards has been approved and a technical committee formed to establish key compliance documents and guidelines for developing SPA components.

### TacSats

In the area of tactical satellites, or TacSats, the Air Force Space Command is leading a series of operational demonstrations of small (less than 500 kg) experimental satellites in cooperation with the Navy, Army, Marine Corps, NRO, and Office of Force Transformation. The vision behind these demonstrations is to offer combatant commanders an adjunct capability to existing

and planned national security space constellations, enabling a wide variety of intelligence, surveillance, reconnaissance, and other missions. TacSats are designed to provide the warfighter with a rapid tactical-mission-tailored operational capability.

The Naval Research Lab is leading the development and demonstration of TacSat-1. At press time it was scheduled for launch by the end of 2005. AFRL is leading the development of TacSats 2 and 3, and Air Force Space Command will oversee the military utility assessment of the satellites. These two spacecraft are scheduled for launch in 2006.

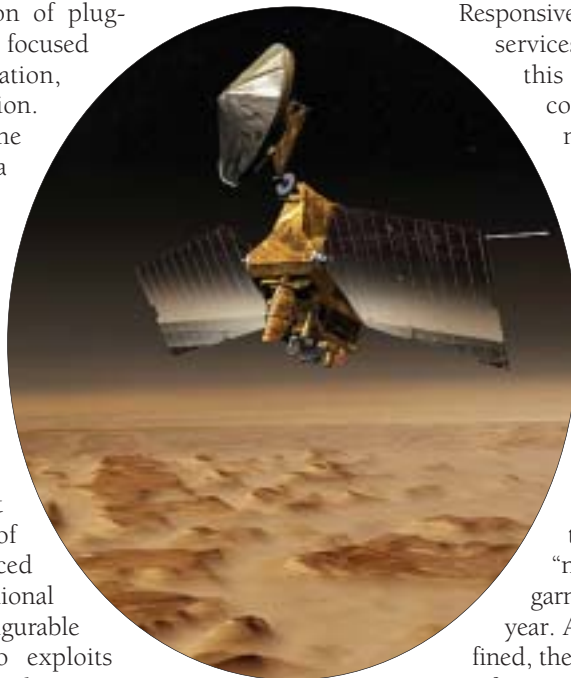
Entrepreneurship is alive and well in the race to meet USAF responsive space needs. The Air Force/Space and Missile Systems Center recently provided a \$100-million contract to Space

Exploration Technologies (SpaceX) for Responsive Small Spacelift launch services. SpaceX will support this contract using its Falcon launch system. The maiden flight of Falcon 1 will carry a TacSat and is scheduled for some time in 2006. SpaceX will use launch sites in California, Florida, and the Marshall Islands.

### Near space

The investigation into the military applications of operating in the "near space" realm has garnered much interest this year. Although not legally defined, the commonly held definition of near space is the region from 65,000 to 325,000 ft (20-100 km). Air Force Space Command has been designated the lead command within the Air Force to examine the uses of near space, and has been very busy over the past year.

The command worked with AFRL to conduct a 90-day near space study. It looked at the military utility, operations, logistics, and capabilities of near space platforms and payloads. Besides studies performed by Space Command, the Scientific Advisory Board, and the National Defense Industrial Association, the Space Battlelab conducted the Combat SkySat demonstration, using weather balloons to lift a communications relay capability and dramatically extending ground-to-ground radio range. ▲



*The Mars Reconnaissance Orbiter was launched on August 12.*