

## Solid rockets

ATK realigned its business operations this year to reflect its evolving role as a provider of comprehensive launch systems. As a result of the establishment of ATK's Launch Systems Group, the name Thiokol, which has long been associ-

*Bristol Aerospace's Black Brant rocket motor is used to power several of NASA's largest multi-stage sounding rockets.*



ated with polymers and propulsion in the U.S., passed largely into history. Until this year, the Thiokol name had survived a number of corporate acquisitions, mergers, divestitures, and business realignments.

A historic milestone was reached in October 2005, when the final Titan rocket was launched from Vandenberg AFB. The Titan IV B version, which began flying in 1997, introduced the ATK-developed SRMU (solid rocket motor upgrade) boosters and delivered 100% mission success for 17 flights between 1997 and 2005.

On August 30, NASA successfully static fired a 17-in.-diam, 210-in.-long Black Brant 5C Mk 1 rocket motor at Edwards AFB, Calif. The Mk 1 motor, manufactured by Magellan-Bristol Aerospace of Canada, contains HTPB propellant and other upgrades of the heritage design that has powered over 425 NASA sounding rocket launches since the early 1970s.

### Launch boost and space systems

NASA continued plans for the use of solid rocket propulsion to launch the newly named Orion spacecraft, formerly known as the crew exploration vehicle. Orion will ride to Earth orbit atop a rocket christened Ares I. The rest of the 550 tons of cargo needed to complete a Mars-bound spacecraft will be hefted into orbit by the massive Ares V. Ares I will use a lengthened version of the space shuttle's current solid rocket booster motor as its first stage. Ares V will also benefit from space shuttle technology, strapping on two of the shuttle boosters to augment main engine launch thrust.

The development of Vega, Europe's future launch system for small payloads, continued in the first half of the year with the completion of a dedicated test facility for the directional control system of the first-stage motor, and the initial static test of its second-stage solid rocket motor (SRM), the Zefiro 23, conducted in Sardinia in June.

Although the 7.5-m-long, 2-m-diam Zefiro 23 is one of the largest composite-cased SRMs ever test fired in Western Europe, it will soon be surpassed by the first planned firing of the P80 Vega first-stage motor, which is 3 m in diameter and 10.6 m long. Testing of the P80's thrust vector control subsystem will continue for several months to verify the control sequence that will be used during the first P80 motor static firing. Additional Vega program milestones reached since September 2005 include the initial static firing of the Zefiro 9 third-stage SRM and key tests of the igniter technology to be used on all three boost motors.

In May, ATK Launch Systems conducted a successful test of its Orion 38HP motor, a high-performance variant of the Orion 38 production motor. The Orion 38HP incorporates several technology enhancements, including a 3-D carbon-carbon exit cone and an improved thrust vector control system, aimed at achieving Phase II goals of AFRL's Integrated High Payoff Rocket Propulsion Technologies program.

In January, Aerojet and Lockheed Martin conducted the third successful test firing of the Atlas V upgraded Block B solid rocket booster at Edwards AFB, following previous tests conducted in the spring of 2005. This design upgrade is intended to provide robust thermal margins and enhanced reliability for the Atlas V.

### Missile defense and strategic systems

ATK Elkton successfully completed a proof-of-concept test firing of a second-stage rocket motor for the Missile Defense Agency's (MDA) ki-

netic energy interceptor. This was the first of a planned series of first- and second-stage static firings leading to the first booster flight in 2008.

On January 18, an ATK Elkton-manufactured Orbus 1A upper stage was successfully static tested at simulated altitude conditions at Arnold AFB, Tenn., marking the completion of transition from former supplier Pratt & Whitney Space Propulsion. The Orbus 1A is used as the second and third stages of MDA's boost vehicle interceptor.

Demonstration of Aerojet's flight booster motor for the terminal high altitude area defense (THAAD) interceptor continued in July, with the successful intercept of a Hera target vehicle at White Sands Missile Range. This test marked the third successful flight test of an Aerojet THAAD booster since November 2005, following the transfer of the booster production program from Pratt & Whitney Space Propulsion.

Also in July, the team of Raytheon and Aerojet demonstrated the capability of a throttling divert and attitude control system (TDACS) for the Aegis ballistic missile defense program's Standard Missile-3 (SM-3). TDACS, a propulsion and maneuvering system for the SM-3's kinetic warhead (KW), makes use of a solid propellant gas generator that can be throttled to alternate between high thrust and coast periods. Ten proportional pintle thrusters are used for lateral movement of the KW, and to maintain the seeker's angular alignment.

In March, Aerojet announced an award from the Air Force for a second-phase contract to develop and test a full-scale SRM for application on potential ICBM systems. During the next four years, Aerojet will design, fabricate, and test two full-scale second-stage SRMs, drawing on their past experience in developing stages for the Peacekeeper and Small ICBM.

ATK and Lockheed Martin successfully test fired a second-stage booster motor as part of the Navy's booster system demonstration for the SLIRBM (submarine launched intermediate range ballistic missile) in August. The modified second-stage Orion 32-4 high-performance booster motor was fired for 40 sec at maximum thrust at ATK's test facility in Promontory, Utah. In a July test, a modified Orion 32-7, the first stage for the prototype two-stage propulsion system, underwent static firing. Both tests demonstrated the integrated operation of the motor with a Moog-developed electromechanical thrust vector control system. The booster demonstration is part of the first phase in the development of a new submarine-launched supersonic missile capable of reaching intermediate-range targets within 15 min.

In November 2005, the German propulsion company Bayern-Chemie/Protac conducted the first free-flight test of the missile designated LFK NG using a dual-pulse solid rocket motor. The LFK NG is a future modular air defense missile system optimized for vertical launch and engagement of non-line-of-sight targets. This dual-pulse solid rocket provides the energy management needed to meet the missile's kinematic performance requirements. The LFK NG demonstration program concluded in April with the successful second flight test in Meppen, Germany.

### Tactical and gun-launched systems

A successful test firing of Meteor, the future European air-to-air missile, was accomplished in June. After separation from the launch aircraft, a solid propellant booster motor powered the missile to above Mach 2 where transition to the ramjet sustainer occurred. Prior to the air-launched demonstrator flight test program, the



*Bayern-Chemie/Protac's rocket-ramjet propulsion system for Meteor is powered to transition velocity by an integrated nozzleless booster motor.*

reduced-smoke, nozzleless integrated booster underwent extensive testing at Bayern-Chemie/Protac and the Meppen proving ground.

In April, ATK successfully fired a ballistic trajectory extended range munition rocket motor in support of the Navy's Extended Range Munition program, which will provide a high-accuracy, long-range precision projectile. During this boosted, unguided test shot, the rocket motor ignited and achieved a full burn after the round exited the gun barrel. Plans are under way for a series of boosted and guided flight tests.

ATK also reported successful demonstration of its guided MRM-KE (midrange munition kinetic energy) precision projectile. During testing at the Yuma Proving Grounds, the MRM-KE round was fired from an M1 Abrams battle tank and reached a speed of approximately Mach 4 with the aid of a solid rocket motor. Embedded thrusters were used to provide maneuvering capability during the test flight. 75