Space transportation

by **Leon McKinney**
and the AIAA Space Transportation Technical Committee

This year saw significant advances in space transportation efforts both in the U.S. and abroad, particularly in private efforts.

RTF and the space exploration vision

Space Shuttle Return to Flight (RTF) continues, driven by President Bush's Vision for Space Exploration goals: resuming safe, reliable shuttle flight; completing the International Space Station; and retiring the shuttle by 2010.

NASA has made significant progress understanding debris environment and material characteristics of orbiter and external tank (ET) thermal protection systems (TPS). The primary RTF goal is modifying the ET to reduce debris release to below orbiter damage tolerances.

NASA Kennedy is processing all three orbiters. ETs are being modified with the new TPS configuration; orbiter TPS inspection/repair techniques are maturing; analysis validation tests are under way; and the crew, the ground controllers, and the mission management team are training for the RTF mission STS-114, currently scheduled for next summer.

The da Vinci Project vehicle was one of the competitors for the Ansari X-Prize.

Additional warning devices and procedures will handle risk due to analysis uncertainties that will remain until flight validation of vehicle modifications. NASA will emphasize on-orbit inspection and contingency capability to sustain the crew on-orbit if irreparable damage to the orbiter occurs. STS-114 will fly with an orbiter boom sensor system equipped with a laser dynamic range imager (LDRI) sensor. Also, a laser camera system will be used for TPS damage detection requirements exceeding LDRI detection capability. Both sensor systems will inspect the orbiter TPS, reinforced carbon-carbon wing leading edge, and nose cap.

On-orbit TPS repair is under development. The shuttle and ISS programs have been defining and planning contingency shuttle crew support as a last resort in case of irreparable orbiter damage; analyses show that, for at least the first two flights, rescue missions can retrieve the crew of the damaged shuttle from the ISS.

The president's announcement in January of a new initiative for human missions to the Moon and Mars may require a new, super-heavy, Saturn-V-class launch vehicle. Although NASA has not formally stated such a requirement, without a super-heavy lifter, significant on-orbit integration—historically risky and expensive—would probably be necessary. Alternatives for such super-heavy lifters include shuttle- and EELV-derived or "clean-sheet" vehicles.

In September NASA selected 11 companies for Crew Exploration Vehicle and human lunar exploration architecture and concept studies.

Commercial launch vehicles

Since the December 2002 failure of the Ariane V 10-ton configuration, five standard Ariane Vs have been successful, including the Rosetta comet probe mission to rendezvous with the comet Churyimov Gerasimenko in 2014. The next Ariane V 10-ton flight was planned for this fall, with requalification of the Vulcain 2 engine nozzle that caused the 2002 failure. The 10-ton configuration will have a new cryogenic upper stage, the ESCA. In 2005, the lower stack of Ariane V will launch the ATV logistics vehicle to ISS with four times the payload of the Progress logistics vehicle.

Next for Ariane V will be upgrading the ESCA stage to an ESCB stage with the new Vinci engine. The Vinci's improved performance is required for Ariane dual-launch to GTO orbit around 2010. ESCB will be restartable, offering more mission flexibility than ESCA. All Vinci engine components have been tested; the first engine testing is planned for the end of 2004.

Lockheed Martin's Atlas program extended its record of successful missions to 73 with five launches through September (four Atlas IIs, one Atlas III), including the final flight of the Atlas II that flew 63 consecutive successful missions over 12 years. One additional 2004 Atlas V mission is scheduled for launch this month. After 584 missions, the Atlas program has evolved to the Atlas V for the U.S. EELV program and commercial satellite customers.

Lockheed Martin began construction of its new Atlas V Vandenberg launch site in January. The 37th Titan IV mission since the first in 1989 launched a Defense Support Program satellite in February. Two remaining Titan IV launches will occur in 2005.

The Boeing Delta II program also continued its string of successes in 2004 with five missions completed through August. Two USAF GPS satellites were launched from Cape Canaveral. Delta IIs also launched three NASA spacecraft—the long-awaited Gravity Probe-B science mission and Aura Earth-observing mission from Vandenberg and the seven-year Messenger Mercury planetary exploration mission from Kennedy.

Boeing's Delta IV Heavy, the first all-liquid, three-booster-core vehicle, was to debut by the end of this year. Five milestones toward the inaugural Delta IV launch were completed: two propellant tanking tests; a simulated flight test; the encapsulation, hoisting, and mating of the spacecraft to the launch vehicle; and one of two planned countdown rehearsals. Delta IV was designed as the Boeing EELV entry.

Another GPS launch and two NASA missions, SWIFT and Deep Impact, remain on Delta's 2004 manifest.

Meanwhile, debate over assured space access continues between the Bush administration, Congress, and industry. While there is general agreement that the current combined DOD and commercial space launch markets will not sustain two EELV vendors, leading some in the administration and Congress to call for a down-select to a single provider for budget efficiency, opponents argue that would introduce unacceptable risk. The Air Force has asked retired Gen. Thomas S. Moorman to update by the end of 2004 the 1994 Space Launch Modernization Panel he chaired that started the EELV program.

X-43A

On March 27, the X-43A hypersonic test vehicle was launched from a NASA B-52B aircraft to the Pacific Ocean test range off the California coast. A modified Pegasus rocket boosted the X-43A to 95,000 ft, where the test vehicle separated and flew under its own power to more than Mach 7, approximately 5,000 mph, faster than any known aircraft powered by an air-breathing engine has ever flown. The vehicle then landed in the Pacific.

Initial data reviews confirmed that high-fidelity flight data were obtained throughout the vehicle's boost, stage separation, and descent flight segments to splashdown. "The data clearly show, and without question, that scramjets work," said X-43A chief engineer Griff Corpening of NASA Dryden.

Significant aviation milestones occurred during this combined effort by NASA Langley and Dryden and their industry partners, including the first controlled, accelerating scramjet-powered free flight and the first successful stage separation at high dynamic pressure of two non-axisymmetric vehicles. The next X-43 flight will be at Mach 10, approximately 7,500 mph.

Ansari X-Prize

Two teams, the American Scaled Composites and the Canadian da Vinci Project, announced plans to capture the Ansari X-Prize in 2004. The X-Prize, a $10-million award intended to foster space tourism, was to go to the first team to successfully launch a privately funded spacecraft to 100 km with three persons on board and repeat within two weeks. Scaled Composites had already made history on June 21 when its SpaceShipOne flew to over 100 km, allowing pilot Mike Melvill to earn his astronaut wings. On September 29, in a flight filled with over 25 unscheduled rolls, Melvill completed the first attempt (carrying weights rather than two passengers). Then, on October 4, this time with pilot Brian Binnie at the helm, the team repeated the flight and the prize was won.

DARPA and the USAF awarded Lockheed Martin $8.4 million to develop the FALCON hypersonic cruise vehicle concept.

Air Force and DARPA programs

The Air Force is finishing its ORS analysis of alternatives. ORS advocates envision capabilities to deploy weapons, surveillance, and space control payloads to support combat operations. New emphasis on the TacSat demonstration series suggests that an experimentation approach is being considered to implement ORS.

DARPA's FALCON program will develop near- and far-term capability to execute time-critical, global-range missions. In the near term, FALCON-developed low-cost, responsive, small launchers will be used to boost Common Aero Vehicles to suborbital velocity, delivering 1,000-lb payloads at global range with unpowered hypersonic glides. For the far term, reusable hypersonic cruise vehicles will deliver 12,000-lb payloads 9,000 mi. in less than 2 hr.

In August, DARPA and the USAF awarded Lockheed Martin $8.4 million for Phase IIa of FALCON Task 2, a six-month preliminary design of hypersonic technology vehicle prototypes. Then the company will begin a $97-million, 30-month Phase IIb—detailed design, fabrication, and flight test of an initial hypersonic technology testbed vehicle. Spiral development will lead to multiple flight demonstrations in Phase III.