Aerodynamic decelerators

This was an exciting year for the military and space aerodecelerator community. Several military parachute programs showed substantial performance and acquisition-related maturation. The airdrop community is experiencing a paradigm shift in the operational use of precision delivery systems.

In the space domain, aerodecelerator technology played a prominent role in the success of the Cassini-Huygens Saturn mission. There has also been significant enthusiasm generated by the government's new Space Exploration Initiative. Several projects focused on aerodecelerator technology will pave the way for this vision, and for the first phase of the new Crew Exploration Vehicle (CEV) program, which will likely feature a human-rated parachute landing system for Earth reentry.

The Screamer parafoil system deploys a secondary parachute for landing.

Military systems

The Army Natick Soldier Center (NSC) sponsored another Precision Airdrop Technology Conference and Demonstration (PATCAD) in October at the Yuma Proving Grounds to showcase state-of-the-art precision airdrop technology. Held every two years, PATCAD provides an opportunity for national decision-makers, program managers, and engineers to demonstrate the substantial achievements made by government-funded aerodecelerator projects. Over 500 attendees from more than 15 nations participated, with support from NATO, USAF, SOCOM, USMC, U.S. TRANSCOM, U.S. JFCOM, and others. PATCAD offered attendees a clear vision of the future of military resupply and precision airdrop.

In its second year, the Joint Precision Airdrop System (JPADS) Advanced Concept Technology Demonstration (ACTD) saw significant progress. The highest priority DOD airdrop science and technology program, JPADS is working toward accurate delivery of 10,000-lb, or 10K, rigged weight precision airdrop systems that are deployable from 25,000 ft mean sea level. Previous government-funded programs have developed several mature 2,000-lb precision airdrop systems—the MMIST Sherpa, the 2K Screamer, and the Affordable Guided Airdrop System (AGAS)—that are being tested for operational deployment. The 10K payload airdrop capability offered a substantial design challenge, requiring high precision—100-m circular error probability—at low cost (less than $6/lb of cargo).

The JPADS ACTD, under NSC management, conducted multiple airdrop tests. Initially two competing airdrop systems were evaluated. The first, Dragonfly, deploys a large (3,500-ft^2) parafoil with a high glide ratio (over 3.5:1) and a soft landing capability. The second system, the Screamer 10K, deploys a small, highly wing-loaded parafoil immediately after exit from the aircraft and then deploys a cluster of two round parachutes (G-11s) at low altitude for landing. This system has moderate glide capability, but offers low time aloft and uses existing Army inventory assets.

Following rigorous testing that demonstrated autonomous flight of each system at the objective weight of 10,000 lb, the Screamer, which is being developed by Strong Enterprises and Robotek Engineering, was selected for continued development under the ACTD. Future military funding will continue to mature heavy-payload, precision airdrop systems, with a near-term goal of developing a cost-effective 30,000-lb system.

Vital to the JPADS vision for future precision airdrop is the continued maturation of an integrated mission planning (MP) software. The JPADS-MP is being developed by Planning Systems, Draper Laboratory, and the NOAA Forecast Systems Lab to support a wide variety of guided and ballistic airdrop systems. The MP software provides high-fidelity weather forecasting in conjunction with a generic GUI (graphical user interface) mission-specification capability. There was progress this year in integrating the software with an assortment of airdrop systems. The JPADS-MP is being used to support military free-fall operations, and has been linked via a wireless common navigation interface unit to the 10K and 2K Screamer, the 10K Dragonfly, the MMIST Sherpa, and the Capewell/Vertigo AGAS for use in upcoming high-altitude tests to support rapid fielding initiatives.

Following a government technical evaluation, the Para-Flite MTR-1 main parachute was

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selected to proceed into Advanced Tactical Parachute System (ATPS) preproduction qualification testing and ultimately to replace the Army T-10 parachute system. Variants of the T-10 have been in use since the 1950s; however, increased loads carried by current airborne soldiers required a significant performance improvement to the standard personnel chute. The Para-Flite canopy allows the jumper to carry more weight and provides a 25% lower rate of descent than the T-10. This significantly lowers the resultant impact energy and is expected to reduce landing injuries. The unconventional design is a highly modified cross-shaped canopy with an inflated diameter 14% greater than that of the T-10, with 28% more surface area. Expected to be in service in 2010, the ATPS canopy will be named the T-11.

The Army's Product Manager Force Sustainment Systems program, located at NSC, was tasked with developing a new low-cost aerial delivery system. The goal is to develop a low-cost airdrop container, and both high- and low-velocity parachutes as alternatives to existing container delivery system components. The design is aimed at one-time use for humanitarian relief and resupply missions when recovery of the components is impractical or impossible. Many innovative methods of parachute construction, suspension line rigging, and fabric stitching have been implemented to reduce manufacturing costs by 60%. Testing to date has been very successful, with loads up to 2,200 lb and altitudes up to 25,000 ft.

Space systems

This year began with the successful entry and descent of the Huygens probe into the dense atmosphere of Titan. The 319-kg probe separated from the Cassini orbiter in December 2004 and began a 20-day coast toward Titan. Just 4 hr before reaching Titan's atmosphere, timers awoke the probe and a three-parachute deployment sequence was used to decelerate it for landing and to provide a stable platform for scientific measurements. The probe featured six different instruments for atmospheric sampling, wind profiling, surface imaging, and a complex array of surface science experiments.

On-board instrumentation successfully relayed collected data through the Cassini orbiter back to Earth, where it is currently being analyzed. Huygens' data and ongoing orbiter observations should provide a wealth of information on the virtually unknown atmospheric conditions of Saturn and its moons.

Work continues on the Phoenix Lander Mars mission, scheduled for launch in 2007. Its entry, descent, and landing (EDL) scheme will begin with atmospheric entry using a 70-deg sphere-cone forebody, followed by deployment of a disk-gap-band parachute, and then a completely propulsive descent to reduce vertical speed for final impact on landing legs. NASA aerodecelerator technology projects have also been implemented to support the Mars Science Laboratory and other future robotic missions to Mars. A development and test program is examining the utility of parachute wind drift compensation (WDC) control for enabling precision (pinpoint) landing. Concepts for WDC have focused mainly on using movable slots/flaps on a round canopy to provide limited glide-slope control and improved terminal accuracy.

Mars EDL parachute technology is advancing with plans for large subsonic parachute qualification tests. All Mars missions to date have used supersonic, disk-gap-band parachute technology developed under the Viking program. Parachute qualification tests for Mars entry are extremely expensive—tests must be conducted at very high altitudes (around 100,000 ft) under high speeds to allow examination of inflation characteristics. Work is under way to develop a large subsonic parachute that could be used on Mars to increase possible payload weights or increase the available landing elevations. Following full-scale wind tunnel loads testing, plans call for a series of high-altitude deployment tests.

The Advanced Tactical Parachute System, slated to replace the T-10 personnel chute, undergoes flight testing.

A host of other aerodecelerator R&D projects and Capability Roadmap activities were undertaken to support NASA's Vision for Space Exploration. Current system baselines for the CEV call for ballistic Earth reentry rather than the gliding approach used by the shuttle. Thus there will be greater emphasis on parachute reliability, wind forecasting, and overall aerodecelerator performance characterization. Aerodynamic decelerator systems will also play a vital role in the formidable task of depositing extremely large payloads on Mars for future manned missions. Several exciting technology thrusts are being explored, including development of large inflatable decelerators, and significant efforts involving aerocapture and reentry guidance algorithms.