# Aerodynamic decelerators

by **Chris Madsen**

This year brought numerous successes in the areas of planetary exploration and military applications, resulting from years of parachute research and technology development. Aerodynamic decelerator systems played a vital role in the success of several significant missions this year. Parachutes were used for the safe entry, descent, and landing of both Mars missions, and airbags cushioned the touchdown of the two Mars Exploration Rovers. Continuing military efforts have increased the need for low-cost precision delivery of cargo and troops by parachute. Recent developments in the Joint Precision Airdrop System and other DOD programs have shown great progress in this area.

*Test of a 10,000-lb Screamer system at Yuma Proving Ground was part of the JPADS technology program.*

## Planetary systems

This year began with the successful capture of thousands of particles from the comet Wild 2 by the Stardust spacecraft on January 2. Stardust flew within 236 km of Wild 2 at nearly 13,000 mph. Stardust's Sample Return Capsule is currently scheduled to return to Earth in January 2006, and the use of aerodynamic decelerators will safely recover the cometary samples.

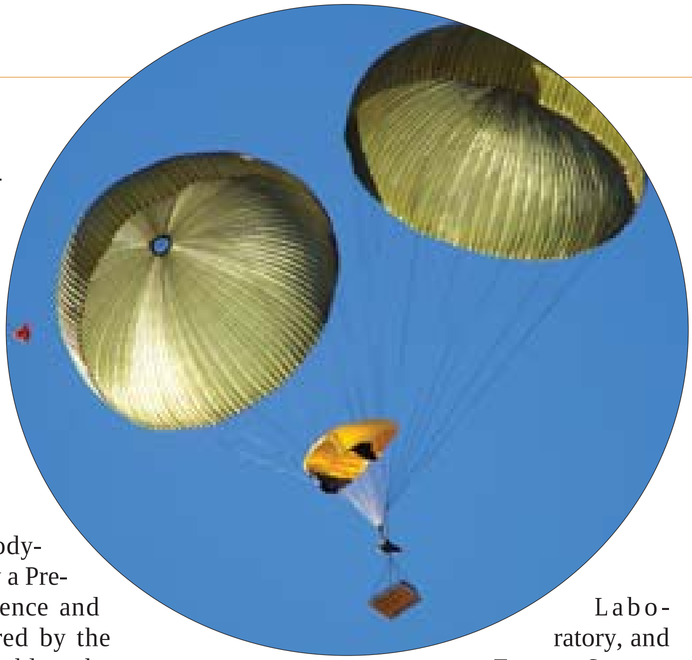
Immediately following the Stardust comet encounter, the Mars Exploration Rover (MER) Spirit performed a successful entry descent and landing (EDL) in Gusev Crater on the surface of Mars. Its descent was slowed using a hybrid disk gap band (DGB) parachute manufactured by Pioneer Aerospace. Airbags manufactured by ILC Dover were inflated to cushion the landing. Upon reaching the surface, the craft bounced nearly a dozen times, stopping approximately 250 m from the initial impact point. Later in January, the MER Opportunity performed another successful Mars landing with an identical DGB parachute and airbags on the plains of Meridiani.

Elsewhere in the solar system, the Genesis spacecraft, which had been collecting solar particles, returned to Earth on September 8. Regrettably, the drogue parachute deployment mechanism was never initiated (for reasons that are currently under investigation), so the planned midair retrieval of the spacecraft could not be performed. However, mission scientists now believe that enough of the solar wind collectors were sufficiently undamaged that it may be possible to achieve the most important parts of their science objectives.

On June 30, the Cassini-Huygens spacecraft successfully entered orbit around Saturn. This set up the planned release on November 6 of the Huygens probe, developed by ESA, and its eventual plunge into Titan's thick atmosphere next January. Three parachutes will be used during the probe's descent. At a speed of Mach 1.5, a 2-m pilot chute will be deployed and will immediately deploy the 8.3-m main parachute. After approximately 15 min, the main parachute will be released, deploying a smaller 3-m drogue chute. The spacecraft will touch down on the Titan surface at 7 m/sec.

These events all followed the January announcement of President Bush's new Space Exploration Initiative: Earth, Moon, Mars, and Beyond. The Vision for Space Exploration calls for a building-block strategy of robotic and human missions to achieve new exploration goals. Aerodynamic decelerator systems will play a vital role in the achievement of the initiative. Parachutes will be used for the stabilization and deceleration of both human and robotic EDL systems and will have a significant role in crew escape systems, increasing spacecraft safety and reliability. Inflatable technology will be studied to determine the benefits of inflatable aeroshells for aerocapture and Earth or Mars entry. Airbag technology will continue to be used to provide soft landings for robotic probes, and possibly human missions.

Several relevant recovery system tests were performed at Yuma Proving Grounds this year. Lockheed Martin and NASA Johnson tested a 25,000-lb payload recovered using a Pioneer Aerospace-developed 80-ft ribbon drogue chute and a cluster of four 156-ft-diam ringsail main parachutes developed by Irvin Aerospace. This test successfully demonstrated a possible crew escape recovery system for a pad abort. Irvin Aerospace also completed a test program on behalf of Lockheed Martin, which provided valuable technology demonstration for the safe landing of space reentry vehicles using airbag impact attenuation. The test article, weighing 11,500 lb, used a suite of four airbags. Each airbag consisted of a vented outer main bag that provided the primary impact attenuation, and an inner anti-bottoming bag to ensure that the vehicle did not impact the ground.



*Full-scale wind tunnel tests of the MER disk-gap-band parachute were performed at NASA Ames.*

## Military systems

This year's military testing of aerodynamic decelerators was kicked off by a Precision Airdrop Technology Conference and Demonstration (PATCAD), sponsored by the Army Natick Soldier Center and held at the Yuma Proving Grounds at the end of 2003. PATCAD is held every two years, with parachute developers and manufacturers gathering from all over the world to witness demonstrations of state-of-the-art airdrop systems.

The highest priority DOD Airdrop Science and Technology program, known as the Joint Precision Airdrop System (JPADS) Advanced Concept Technology Demonstration (ACTD), made significant progress in its first year. JPADS is working toward the accurate delivery of 10,000-lb rigged weight precision airdrop systems that are deployable from 25,000 ft MSL (mean sea level). The JPADS ACTD is a multiservice, multiorganization, multicontractor effort scheduled to conduct three military utility assessments in FY06 and transition residual systems to selected users for operational use during FY07-FY08.

Two 10,000-lb decelerator systems are being considered for JPADS. The first is a large parafoil system being developed by Para-Flite, Wamore Associates, Robotek Engineering, and Draper Laboratory. The parafoil features a suspended airborne guidance unit that controls the parafoil for precise landings. The second is the Screamer system, which is being developed by Strong Enterprises and Robotek Engineering. Screamer utilizes a high wing-loaded ram-air controllable parafoil at high altitudes for guided descent and deploys traditional cargo parachutes near the ground for a soft landing. Both systems have been tested repeatedly at rigged weights of 8,000 lb at 15,000 ft MSL and are successfully flying autonomously.

Each of these systems will be tested from USAF aircraft numerous times by the end of the year. They are being integrated with the Precision Airdrop System (PADS), a mission planning system and weather forecast/collection system being developed by Planning Systems, Draper Laboratory, and Forecast Systems Laboratory. PADS also successfully completed two operational utility evaluations showing significant improvements in accuracy for high-altitude ballistic airdrop systems.

The Capewell/Vertigo electromechanical G12-based affordable guided airdrop system, which was successfully demonstrated last year, has passed all subsequent tests with incredible accuracy and reliability. It is now truly mature, being 100 lb lighter, more compact, easier to rig, and user friendly, with features such as removable mil spec batteries and flight control unit. These systems were recently deployed 23 times from 13,000 ft above ground level, with all containers landing within 300 ft of the target (CEP for all drops is 145 ft) with no malfunctions. With the continuing war efforts, the ability to deliver military personnel safely and resupply troops accurately will increase in importance.

## European activities

The Europeans also achieved significant advances this year. The Small Parafoil Autonomous Delivery System developed by the Dutch Space and National Aerospace Laboratory (NLR) is now operational. This parafoil is capable of delivering up to 200 kg from a C-130 within 200 m accuracy. The ParaFinder, a new and globally unique mission planning and navigation system for high-precision parachute jumps from high altitude, was developed by EADS and is now operational.

R&D of the Foldable Adaptive Steerable Textile Wing (FASTWing) has also progressed. Under development by Autoflug (Germany), CIMSA Ingenieria de Sistemas (Spain), CESA (Spain), EADS-ST (Germany), NLR (Netherlands), and DLR (Germany), the FASTWing program aims for the creation of a new parafoil design suitable for precision delivery of heavy payloads up to 3,200 kg.