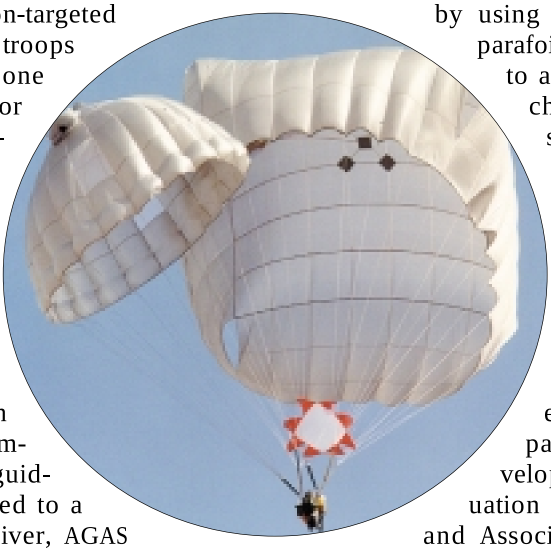
AEROSPACE SCIENCES

Aerodynamic decelerators

by **Dean S. Jorgensen**

Early one sweltering September morning in Yuma, Ariz., 130 engineers, technicians, and military personnel from the U.S. and a half-dozen allied nations were preparing for the long drive into the desert for a day-long demonstration of the world's most modern computer-controlled cargo parachute systems. Then news began trickling in of a fire at the World Trade Center in New York. The date was September 11, 2001, and, ironically, the technologies these designers and potential users had come to evaluate were the very systems that will one day allow delivery by air of the critical warfighting materiel and relief supplies needed to support operations in barren, remote areas like the mountains of Afghanistan.

Low-cost, precision-targeted delivery of cargo and troops by parachute remains one of the holy grails for aerodynamic decelerator technologists. Emphasizing low cost, the Army demonstrated its Affordable Guided Airdrop System (AGAS), basically a conversion kit for standard round cargo parachutes such as the venerable 20-m-diam G-12. Using a guidance computer coupled to a commercial GPS receiver, AGAS features pneumatic muscle actuators developed by Vertigo to deform the otherwise round canopy, generating the glide necessary to correct for wind drift and release point error.



Advanced Tactical Parachute System undergoes technical feasibility testing of its reserve parachute.

Software modeling, flight testing

Knowing where to release a load is as important as being able to steer to the target. Planning Systems and Draper Laboratory engineers are now combining mesoscale atmospheric models with data from atmospheric dropsondes to generate 3D wind and density fields consistent with the local terrain. This precision airdrop planning software can now be used to calculate highly precise computed air release points, improving the efficacy of traditional ballistic airdrop systems.

While NASA is suspending development of the International Space Station Crew Return Vehicle for budget reasons, testing of the X-38 parafoil landing system goes on. Pioneer Aerospace's 700-m^2 parafoil—the world's largest ram-air parachute—performed flawlessly in the latest flight test of the 8,000-kg X-38 prototype vehicle. The onboard GPS-based autopilot successfully controlled the parafoil to a soft landing within 100 m of its designated target. Pioneer is now working with the Army and NASA to apply its large parafoil technology to the precision aerial delivery of up to 10,000 kg of critical supplies in a single load.

Military developments

The Army's Natick Soldier Center is exploring a number of other precision airdrop technologies. Strong Enterprises has developed a novel delivery system that starts by using a small, controllable parafoil, and then transitions to a standard round parachute for its final descent. The Army's Precision Extended Glide Airdrop Systems, or PEGASYS, program will lead to an entire family of precision airdrop systems starting in 2005.

Designers are also extending airdrop capability through the development of impact attenuation technologies. Warrick and Associates has successfully soft-landed a 4,500-kg payload using cable retraction, a technique for quickly pulling the parachute toward the cargo just before ground contact. The rapid increase in parachute riser tension causes the payload to decelerate rapidly. The retraction mechanism incorporates a high-pressure compressed gas piston lashed to the center of the airdrop platform beneath the cargo. The electronic controller that regulates gas flow to the mechanism is programmed to produce a touchdown velocity of 2.5 m/sec, about the same as jumping off a 30-cm-tall wall. This newly demonstrated capability supports the Army's objectives for the rapid rigging and derigging of parachute-delivered payloads.

Industry is actively supporting other military-funded development programs. Both Para-Flite and Irvin Aerospace are developing parachute systems capable of delivering platform loads from altitudes as low as 150 m above ground level.

The Army is also exploring nontraditional methods of delivering high-value payloads from extremely long offset distances. In July, Vertigo's Extended Range Aerial Delivery System, a prototype inflatable-wing cargo delivery glider, made its maiden flight.

The Army is well along in its development of the XT-11 Advanced Tactical Parachute System. The ATPS will replace the standard-issue T-10 troop parachute system that has been in use worldwide since the 1950s. Principally used for mass tactical assaults and designed to handle a gross weight of 115 kg (jumper, parachute, and gear combined), the T-10 has served the military well. But modern airborne soldiers jumping out of aircraft are weighing as much as 180 kg. Today's troops are bigger on average than soldiers of past generations, and they are carrying more equipment and supplies. The XT-11, designed and developed by Para-Flite, has demonstrated rates of descent that are 25% lower than the current T-10. Average rate of descent has been reduced from 6.4 to 4.9 m/sec. This corresponds to a 40% reduction in impact energy that will in turn result in far fewer landing injuries. Developmental and operational testing of the XT-11 ATPS will run through 2003. The system will be introduced into operational use in 2004.

Mars mission

Both NASA and ESA are planning trips to Mars in 2003. Leveraging off the technological success of the Viking and Pathfinder missions, JPL's Mars Exploration Rover will descend to the planet's surface underneath a Pioneer Aerospace disk-gap-band parachute.

ESA's Mars Express will carry the Open University's Beagle 2 probe on the European agency's first-ever visit to the red planet. The Beagle 2 will rely on an innovative two-stage parachute system being built by an international team of designers.

Keys to performance and progress

Computational modeling of parachute performance remains key to the design and operation of today's high-performance systems. Sandia National Laboratories, under the Dept. of Energy's Accelerated Strategic Computing Initiative, is developing an unsteady 3D parachute simulation code. The Vortex Inflation PARachute (VIPAR) code will eventually be able to perform complete numerical simulations of ribbon-type parachute deployment, inflation, and steady descent. VIPAR's designers have recently developed an accurate and stable method for coupling the fluid and structural portions of the code. This is significant, because the parachute mass is small relative to the mass of fluid that is accelerated during parachute canopy deployment and inflation.

Testing of the X-38's parafoil landing system continued despite cancellation of the Crew Return Vehicle program.

Worcester Polytechnic Institute has recently measured the flow field around an inflating parachute canopy as part of an Army Research Office-funded study of parachute aerodynamics. The velocity field was measured using particle image velocimetry. This technique provides sufficient spatial and temporal resolution of the flow around a small-scale canopy to enable detailed studies of the flow field during the inflation process. The results of this research show the significance of the wake formation process on overall canopy dynamics.

The art and science of parachute design continue apace, with more and more demanding requirements placed on high-performance systems—the deceleration of heavier and more maneuverable probes in the Martian atmosphere; rapid deceleration and precise emplacement of smart weapons and electronic sensors; accurate delivery of high-value cargo from extreme altitudes and long standoff; and the soft landing of heavily laden combat troops.

Through advances in computational modeling capabilities, modern high-tenacity textiles, and systems engineering methodologies, aerodynamic decelerator technologists continue to meet the demands of the aerospace community. And with the events of September 11, 2001, still fresh in our minds, those engineers and scientists working in the defense industry, the military sector, and our national labs are doing so with a renewed sense of pride and purpose.