

## TAFSM Researchers Provide Advance Look at Performance of Future Airdrop Systems

by Bob Cramblitt

Bravery aside, jumping from an airplane might seem like a rather simple act. But that act triggers a wide range of influences on the outcome of the jump: What is the air flow around the plane when the paratrooper is exiting through the door? How will unsteady air flow affect the jump? What aerodynamical forces are exerted on the paratrooper at different times? What are the aerodynamics of a paratrooper with an open parachute?

These and many other questions impact how airdrop systems are designed and used by paratroopers on a mission. The answers are being provided by computational scientists using a mix of tools that includes advanced flow simulation and modeling, state-of-the-art computational methods, the world's fastest hardware systems, and high-capacity visualization software. These tools reduce or complement costly field tests and allow scientists to visualize scenarios that could not be simulated in a laboratory.

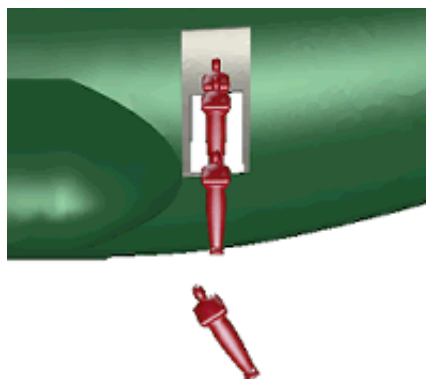
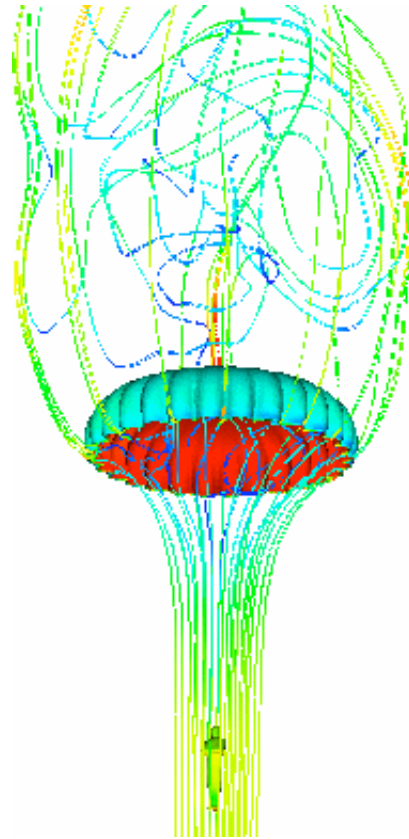
At the forefront of airdrop systems research is the Team for Advanced Flow Simulation and Modeling (TAFSM), a group of researchers that develops advanced computational methods and tools for flow simulation and modeling. TAFSM members include computational scientists from Rice University, Clark Atlanta University, Network Computing Services, the Army HPC Research Center, and the U.S. Army Natick Research, Development & Engineering Center.

### Crunch-time Performance

A 256-processor Cray T3E-1200 supercomputer and Silicon Graphics multiprocessor systems supply the processing power for TAFSM's work. Airdrop simulations are computationally demanding, involving millions of coupled non-linear equations that have to be solved for each time step.

"The size of the simulations has always been a major computational challenge for us," says TAFSM leader Tayfun E. Tezduyar, James F. Barbour Professor in Engineering and chairman in the Department of Mechanical Engineering and Materials Science at Rice University. "The memory and scalability of the Cray T3E-1200 system are making it possible to simulate these problems more quickly and cost-effectively."

Two scenarios are simulated to analyze the real-world factors that influence parachute design and paratrooper deployment. One scenario depicts the aerodynamics and dynamics of a paratrooper jumping from a cargo plane traveling at 130 knots. TAFSM uses its own space-time finite-element formulation and mesh-moving algorithms to numerically simulate the problem on the Cray computer. The other simulation calculates the air flow past an open parachute over time.



## Visualizing the Aerodynamics

Once computations are carried out on the Cray, data is imported into EnSight, a software program from Computational Engineering International (CEI) for analyzing, visualizing and communicating scientific and engineering results. TAFSM's visualizations are made possible by EnSight's support for large unstructured tetrahedral meshes that deform and change connectivity over time. Models used in the visualizations can be quite large, containing up to 40-million elements.

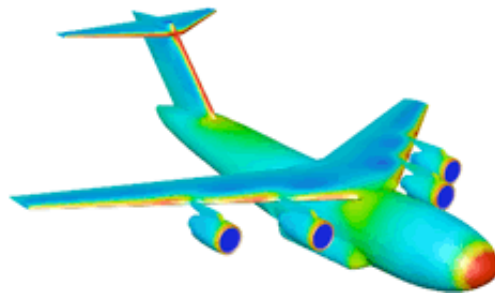


In the aircraft/paratrooper scenario, the EnSight visualizations use color bands to show the aerodynamic pressure distribution on the paratrooper and the aircraft's surface. The position and orientation of the paratrooper are shown at different instants during the simulation.

The open parachute simulation includes about 1,300 time steps or 65 seconds of real time. The EnSight visualization displays pathlines colored with the magnitude of velocity starting at the same location for three different instants. It also shows surface pressure distribution at the instant the pathlines were started.

## A Window into the Future

A Silicon Graphics Onyx2 Infinite Reality2 with two CPUs and a 20-CPU Onyx Reality Engine II are used to compute TAFSM's visualizations. "Multiprocessing support within EnSight dramatically shortens the time needed to compute particle traces and other attributes," says Dr. Marek Behr, a TAFSM researcher. EnSight's client/server architecture allows researchers to perform much of the intensive data processing on the high-end Silicon Graphics servers, then view the results on their desktop screens.



Once visualizations are created, TAFSM researchers can save the set of variables and use them later with similar sets of data, saving time in generating future visualizations. TAFSM adds another dimension to its visualizations by outputting them in real 3D so they can be viewed with StereoGraphics' CrystalEyes eyewear. Stereo 3D graphics gives depth to images and a feeling of immersion. It is especially valuable for flow simulations, since it allows computational researchers to place themselves inside complex geometry in order to see things in a different perspective.

TAFSM's visualizations are a critical window into the potential performance of airdrop systems under development by the U.S. Army and NASA. "Visualization is the only way to view results from large-scale simulations," says Behr. "The rendering needs to be good enough to have fine control over the appearance of the objects." Most importantly, says Behr, the visualizations must communicate. "High-quality images are valuable in presenting information to those who are supporting our research. You need to be able to display important attributes such as flow fields, isosurfaces, particle paths, velocity vectors and pressure contours."

Output options are important as well. TAFSM has the flexibility to output EnSight visualizations as MPEG and VRML files for distribution via the Internet/intranet, and as RGB, PICT, TARGA, JPEG and PostScript for integration with documents, videos and other media.

Using ever-greater computing power, advanced computational methods and a new generation of visualization tools, TAFSM researchers are continually stepping into the frontier of what used to be impossible to simulate and visualize. While they might never jump out of an aircraft themselves, they are providing a wealth of useful information to those who will in the future.

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*More information on the TAFSM and its research projects can be found at <http://www.mems.rice.edu/TAFSM/>.*