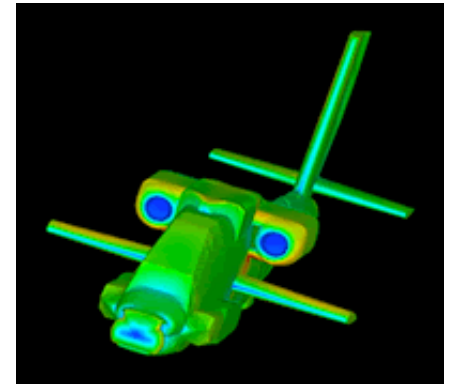


## Parallel Computing, Visualization and VR Could Help Penn State Cut Aircraft Noise

Excessive noise is a part of almost everyone's life, whether it comes from the neighbor next door running his leaf blower or cars driving by with stereos blasting.

But for those who live near airports or Air Force bases, noise is a constant distraction that can cause stress and other health-related problems. Noise from aircraft has been blamed for hearing problems, sleeplessness and lack of concentration leading to problems with school and work.



For the military and commercial airlines, more stringent noise emission standards are increasingly becoming an issue, as they must try to meet federal guidelines or face restrictive night-flight rules, increased no-fly zones, and additional airport fees.

For these reasons, industries, the government and educational institutions such as Penn State University are conducting research to help reduce the noise pollution caused by jets and helicopters. Penn State's aerospace engineering department has been using high-end parallel computers, virtual reality systems, and advanced visualization software to test the causes of aircraft noise and find ways to reduce it.

### More Than Just a Loud Engine

While engines cause the majority of the noise associated with aircraft, aerodynamic noise is also a contributor. This noise comes from atmospheric wakes, turbulent airflow passing the fuselage and wings, and a phenomenon called flow separation, an uneven airflow that causes drag, loss of lift, and increased noise and vibration.

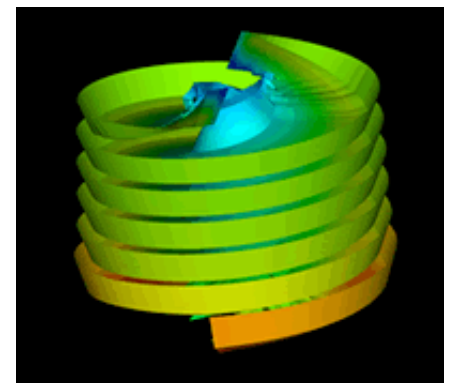
Penn State researchers have been focusing their attention lately on the effects of separated flow on helicopters. But the research could lead to improvements in many types of vehicles.

"Separated flow is very common in airplanes, automobiles, helicopters, trucks, trains and water vehicles," says Dr. Lyle Long, a professor of aerospace engineering involved in the studies. "Being able to predict these flow fields would have an enormous impact on designing better vehicles. They could potentially be more efficient, and also quieter."

### Design Dilemma

The airflow around a complex body such as a helicopter always leads to flow separation causing increased drag and noise. Helicopters also generate a downwash from the rotor blades that can cause additional flow separation on the fuselage, leading to unusual aerodynamic loads and more noise.

"Helicopter fuselages and tail assemblies are extremely difficult to design well, since they often have separated flow," Long says. "It is therefore very important to be able to predict this phenomenon in order to be able to design better helicopters."



To better understand separated flow, Long recently tested the Parallel Unstructured Maritime Aerodynamics

(PUMA) code for generating time-accurate flow data. The goal was to use the code to help predict helicopter airframe noise from complex parts such as landing gear, slats and flaps. The research team used large parallel computers, a RAVE (Reconfigurable Advanced Visualization Environment) VR display, and EnSight Gold software from CEI (Apex, N.C.).

### From Beowulf to High-End Visualizations

Long and his colleagues started out computing uniform airflow using the Ffowks Williams-Hawkings (FW-H) equation, which is often used to predict aerodynamic noise. The PUMA flow solver was then used to obtain time-accurate data on the FW-H surface.

Calculations for the simulations were performed using a Beowulf Cluster named COCOA, a parallel computing system comprising 25 PCs, each with dual 400 MHz Pentium II processors.

"Computational aeroacoustics codes are usually very computationally intensive," Long says. "Even with very powerful machines, such jobs may require days, or even months to give results. Parallel computing using Beowulf clusters offers an inexpensive way to handle such time-consuming simulations in a reasonable amount of time."

When the simulations were complete, Long moved on to the RAVE to visualize the data using EnSight Gold software. The RAVE, manufactured by Fakespace, is a VR system with 8-by-8 foot rear projection display panels that fully engulf the viewer in an immersive environment. EnSight Gold includes standard features for VR systems such as the RAVE, including multi-frustrum support for displaying animations on multiple screens or panels; support for 3D input devices; and a new heads-up monitor (HUM) part-panel interface.

EnSight Gold also provides automatic detection and display of major flow features such as shock waves, vortex cores, boundary layer separation and reattachment lines, surface flow topology, and boundary layer characteristics. The software offers several forms of animation - including flipbook, keyframe, particle trace, plane clips or isosurfaces, model (mesh) movement and load - that makes transient data easier to display and understand.

"Visualization is crucial to evaluating these codes," Long says. "Our simulations are really four dimensional (space and time), so traditional graphics are inadequate. Many of our simulations cannot be understood or interpreted by just looking at a computer monitor. The 3D structure of turbulence, shock waves, and particle simulations require us to look at them in stereographics. In the past, we have had images that we have not been able to understand, but when they are displayed using stereographics in EnSight they are quite easy to interpret."

### A Step Closer to Less Noise Pollution

The combination of high-end parallel computing and sophisticated visualization software is helping to bring the Penn State research team closer to understanding flow separation, which will eventually lead to vehicles that emit less aerodynamic noise, Long says.

"These applications are quite important. We are working on trying to reduce the drag of helicopters, and reducing the noise of aircraft and other vehicles. The work has both civilian and military importance, and it might not be possible without the tools now available to us to compute and visualize the results."

###