Based on a high-resolution multimedia wall 18 feet wide, the Collaborative Visualization Environment (CoVE) offers a new approach to design analysis and decision-making. The Georgia Tech facility can display and manage more than 60 variables.

On the Same Page:

Georgia Tech's CoVE Takes a Collaborative Approach to Design Analysis and Decision-making

By T.J. Becker

Photo: Gary Meek

Georgia Tech's fuel cell-powered aircraft, a collaboration between the Georgia Tech Research Institute and the Aerospace Systems Design Lab, was designed in the CoVE.

"This is the beginning of a new era – the era of visual analytics."

- Dimitri Mavris, director of the Aerospace Systems Design Lab (ASDL)

From fuel-cell powered aircraft and multi-mission cruise missiles to supersonic business jets, engineers at Georgia Tech's Aerospace Systems Design Lab (ASDL) are helping develop the next-generation of land, sea, air and space vehicles. These complex designs involve highly integrated, interoperable systems and enormous amounts of data – which can be cumbersome when presenting a solution to stakeholders.

"How do you visualize hundreds of design parameters, especially in a collaborative environment so decision-makers can discuss the data and come to some kind of consensus?" asks Neil Weston, a research engineer at ASDL.

Enter CoVE, formally known as the Collaborative Visualization Environment. Development of this unique facility was spearheaded by ASDL's director Dimitri Mavris and funded by the U.S. Office of Naval Research. CoVE's focal point is an 18- by 10-foot, high-resolution multimedia wall (about 9.4 megapixels) that can simultaneously display and manage more than 60 variables. A plug-and-play interface at 12 computer workstations allows outside visitors to display information on the wall without having to copy or share files, and IP-based video conferencing technology enables off-site participants to join sessions.

CoVE represents a dramatic change in design reviews. Previously, participants had to huddle around a single computer or use PowerPoint presentations. This meant only 15 percent of information associated with a design could be viewed at a time, requiring researchers to switch from screen to screen and constantly open and close programs. In contrast, CoVE enables decision-makers to see ASDL's solutions in their entirety.

What's more, CoVE manipulates data on the spot. Decision-makers can ask what-if questions and see – in real time – how altering parameters will affect various aspects of a design. "CoVE isn't just a static environment where people go to view information," Weston observes. "It's a dynamic arena where the audience can interact with the data."

Prior to CoVE, decision-makers attended design reviews to be informed rather than to participate, Mavris explains: "If someone asked a question, you would have to get back to them, which could take days or weeks. Even if you had an answer the next day, it was too late; decisions had already been made."

Yet CoVE brings design analysis and decision-making together, says Mavris: "This is the beginning of a new era – the era of visual analytics."

While analytics is about discovering and understanding patterns, visual analytics is "the science of analytical reasoning facilitated by interactive visual interfaces," he explains. "This approach provides a mechanism for a user to see and understand large volumes of information at once. Based on the premise that the brain can best process information received through visual channels, this process facilitates the discovery of unexpected trends and highlights transparency of underlying physical phenomena."

Mosaic of Information

During a design review, ASDL researchers divide CoVE's multimedia wall into sections and allocate them to different disciplines. Suppose researchers are working on a new military jet design: One section of the wall might show a mission-planning tool, another would reflect engine-performance, with other

areas devoted to aerodynamics, economics and life-cycle management issues. Data is interconnected so various tradeoffs – such as safety, environmental impact or costs – can be assessed.

"If you change something in the left-hand corner, all the other charts update, which is very powerful to see," explains Kristin Kelly, an ASDL research engineer. "Decision-makers may have been looking at a design simply from one or two perspectives at a time, such as an engine-performance perspective. Yet when they see the effect on a multitude of perspectives, such as environmental issues, they may have to reconsider to meet regulation constraints."

Making what-if games possible is ASDL's Collaborative Design Environment (CoDE). A sister facility to CoVE, CoDE simulates a war-room setting where ASDL researchers from different disciplines work as a team to introduce physics-based analyses, probabilistic methods, simulation and modeling into the design process at an early stage. Supplying the necessary computational muscle is a cluster with 256 processors, a 7-terabyte storage subsystem and an inifiband (extremely high-speed) network.

One of the techniques ASDL uses to come up with real-time answers is surrogate modeling (also known as meta-modeling). "Rather than using actual codes, you can determine which variables are the most important ones and create a model to manipulate those codes," explains Mavris. "Surrogate models have tremendous accuracy (95 to 99 percent) and also enable you to calculate things instantaneously."

Another benefit: because surrogate models can't be reverse-engineered, they provide a safe way to collaborate without participants having to share proprietary information, Mavris adds.

With CoVE, ASDL engineers have been able to develop new tools and techniques to increase the accuracy of systems design – and increase comprehension for decision-makers. For example:

- A dynamic house-of-quality tool translates customer requirements into engineering characteristics.
- A method for ranking multiple attributes that reveals the best design option based on customer-importance weightings.
- Slide bars on importance weightings so customers can change parameters and

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Photo: Gary Meek

The Collaborative Visualization Environment allows decision-makers to see solutions in their entirety and see the answers to "what-if" questions in real-time.

see what tradeoffs might occur.

- A man-in-the-loop genetic algorithm combines physics-based computing with an experienced engineer to eliminate options a computer might not reject, but which aren't feasible in the real world.

Boon for Business

"CoVE has been a great showcase for ASDL," says Mavris. "Prior to having this facility, it was difficult to communicate to sponsors what we were doing."

Since the facility launched in January 2004, hundreds of engineers, technologists and decision-makers have conducted high-level projects at CoVE including Boeing, General Electric, Pratt & Whitney, Raytheon, Lockheed Martin, Rolls-Royce, the National Aeronautics and Space Administration and the Air Force Research Lab (AFRL).

The latter has used CoVE for technology assessments in three key areas: next-generation unmanned vehicles, long-range strike and directed energy applications.

"These assessments are done in a collaborative environment with industry, academia and other government agencies, so you end up with a very large trade space of ideas," says David Brown, Technology Assessment Office lead at the AFRL's Air Vehicles Directorate. "CoVE provides an environment to break down those complicated problems so we can make smarter investments in allocating resources."

Besides benefiting Georgia Tech's government and industry partners, CoVE plays a vital educational role. Students have full access to CoVE and can use the facility to participate in design competitions and gain experience in design reviews.

"Design is a multidisciplinary activity, so it's important for students to work closely in teams," says Mavris. "At ASDL, students come in as fluids or propulsion specialists, but they leave as more valuable systems integrators."

Benjamin Poole, a graduate student at Georgia Tech's School of Aerospace Engineering and ASDL research assistant, agrees that CoVE has made a big difference in his education. "As an undergraduate, everything is compartmentalized and discipline-specific, so it was initially difficult to get sense of how a complete design came together," he explains. "In CoVE, you can see how data is integrated and make educated decisions based on the manipulations of that data in real time."

ASDL researchers continue to upgrade CoVE's capabilities and explore new visualization tools and processes.

"CoVE has given us a real edge on the competition," says Mavris. "Granted, there are other big walls where people are working on visualization, but this is a blend of modeling, simulation, parametrics and decision-making. CoVE isn't just a place, it's a process where engineers can work together to fuse their data and eventually roll that data up to the appropriate level where risks can be assessed and a business case can close." rh

An aircraft powered by fuel cells takes off on a test run. The aircraft was designed in a collaboration between the Georgia Tech Research Institute and the Aerospace Systems Design Lab using the CoVE.

Photo: Gary Meek

SCoVE:

A Secure CoVE Plus Extras

To support the complex-systems work it conducts for the federal government and industry, the Georgia Tech Research Institute (GTRI) launched a secure version of ASDL's CoVE in June 2007 .

In the SCoVE, researchers can apply techniques developed by ASDL and other Georgia Tech departments along with GTRI's extensive portfolio of network-centric and visualization solutions.

"The primary impetus for the Secure CoVE was to create an environment that enables GTRI to develop robust system solutions for government customers at an unprecedented rate," says Allan Williams, associate director at GTRI's Aerospace, Transportation and Advanced Systems Lab. "The SCoVE allows us to integrate the expertise of the academic departments of Georgia Tech with the decades of experience of GTRI's systems engineers."

The SCoVE features a 24- by 7-foot high-resolution display wall and seats up to 30 individuals. Its state-of-the-art computer network and audio-visual system supports:

- almost unlimited video feeds
- two-dimensional graphics
- remote video inputs and cameras
- DVD, VHS, satellite and CATV
- TCP/IP and UDP encoded video feeds.

The SCoVE has been designed from the ground up to link users at the Georgia Tech campus with GTRI field offices and government facilities across the country in real time. "Instead of going from lab to lab, customers and researchers now can assemble in one room and access all of GTRI's tools," says Williams.

In addition to providing collaborative visualization for systems design, modeling and optimization, SCoVE can also be configured to provide a command-and-control center environment. "This allows us to provide real-world testing of solutions before they're delivered to customers," explains Williams. For example, GTRI's FalconView (a mapping system for flight-planning software) and GTVC (which allows law enforcement, emergency services and other agencies to collaborate online and respond to events) are available at the SCoVE.

"A number of organizations are building CoVE-like facilities, but few offer the visualization and computational capabilities of the SCoVE, and none offers the extensive system-optimization tools and techniques developed at Georgia Tech," concludes Williams.

GTRI's Secure CoVE supports the complex-systems work it conducts for the federal government and industry.

Photo: Gary Meek