Success Story

The U.S. Army Engineer Research and Development Center (ERDC)

Using Numerical Simulation to Help Protect Important Structures from Terrorist Attack

The Challenge

The ERDC needs to improve the blast resistance of important buildings and other structures to help protect them from the increasing threat of terrorist attack.

The Solution

Advanced numerical simulations of blast behavior using advanced computational systems such as the SGI® Origin® 3800 server combined with small-scale and large-scale experiments facilitate the development of advanced wall-window systems that can greatly increase the safety of existing and new structures.

The Result

Government planners now have a growing set of tools at their disposal to protect important structures and the personnel occupying them from the possible effects of bomb blasts.

As terrible as the tragedy of September 11, 2001, was, at least one miracle occurred that day. When American Airlines Flight 77 crashed into the Pentagon, it miraculously struck a section of the building that had been recently retrofitted to resist terrorist attack—the only section of the building that had thus far been refurbished.

Although 125 Pentagon personnel died in the attack, hundreds more lives were spared because of recent modifications. The first and second floors were heavily damaged, but higher floors resisted collapse and surrounding windows remained intact, significantly decreasing casualties and allowing hundreds of people to escape.

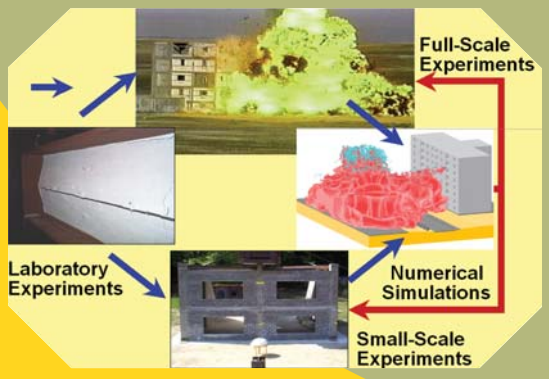
The retrofitting on the Pentagon was made possible by work carried out at the U.S. Army Engineer Research and Development Center (ERDC), in Vicksburg, Mississippi.

A key part of this effort is the simulation of blast effects using advanced supercomputers, many from SGI. An SGI Origin 3800 supercomputer at ERDC simulates a blast wave striking a material and predicts the effects of material failures and fragment debris. Such studies were crucial in creating the blast-resistant wall-window systems used in the Pentagon.

According to Dr. Robert Hall, structural engineer for the ERDC, and chief of the Geosciences and Structures Division, "The key issues addressed by our research are structural collapse and flying debris, since studies have shown these to be the major causes of casualties. Our research involves full-scale experiments, small-scale laboratory experiments, and numerical simulations. Simulations allow us to make good pretest predictions and help us better understand the results from our experiments. The combination of experiment and simulation is allowing us to validate and refine our numerical tools. The end result is a better understanding of blast behavior, which led ultimately to materials and design principles that helped protect the Pentagon. The advanced numerical simulation this requires takes a tremendous amount of computational resources. High-performance computational resources are absolutely essential to this effort."

Using Simulation to Improve Blast Resistance

ERDC uses an SGI Origin 3800 supercomputer configured with 512GB of memory and 4TB of attached disk storage. The computing power embodied in this system makes it possible to rapidly execute the most detailed simulations.



The Cycle of Experiments for Testing Materials

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— Dr. Robert Hall, Structural Engineer,
Chief of the Geosciences and Structures Division, ERDC

"The question is not if but when ... Decisions are now based upon strong experimental evidence and advanced numerical simulation, giving us increased confidence in the results."

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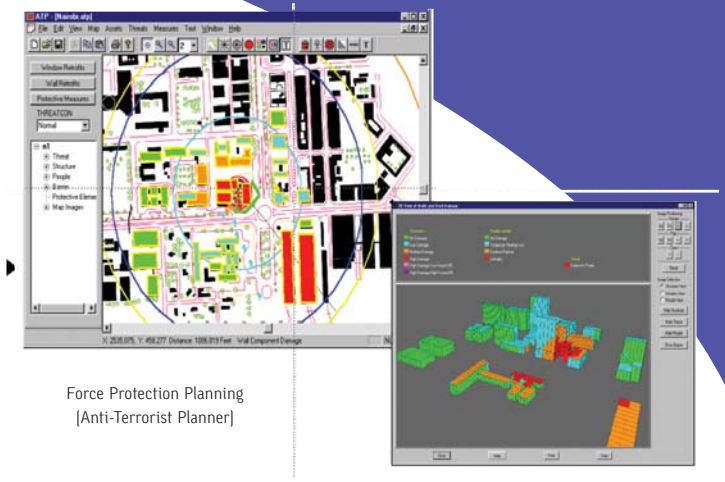

Force Protection Planning
(Anti-Terrorist Planner)

Among its many numerical tools, ERDC uses a number of blast- and shock-analysis codes to simulate the various effects created by an explosion. Because of the size and complexity of the problems under study, a detailed simulation can take literally thousands of processor hours to complete.

"Numerical simulations are crucial to our understanding of blast behavior," said Dr. Hall. "High-performance computational systems allow us to complete more simulations in less time so we can model the behavior of many designs and materials. This in turn helps guide our efforts in designing and selecting blast-resistant wall-window systems appropriate for building retrofits and new construction to ensure greater structural protection."

Advanced Tools for Security Planning

One of the guiding principles at ERDC is that the protection of an important facility is a balance between security activities (controlling the perimeter of the building, controlling access, etc.) and structural hardening.

One of the concrete results of the work performed at ERDC is a set of assessment tools that government agencies can use to determine the safety of existing or planned facilities. The Anti-Terrorist Planner includes features for site definition, safe standoff calculation, vehicle barrier planning, structural window/hazard analysis, and protective/retrofit measures. These tools distill the benefits of years of research into practical guidelines to help protect important infrastructure at home and abroad.

SGI® NUMAflex™: The Architectural Advantage

The SGI Origin 3800 server at ERDC features a single system image (SSI) and global shared memory. All processors access all system memory directly. This is in sharp contrast to clustered solutions in which a separate instance of the operating system is needed for every few processors and each processor has direct access to only a subset of total memory.

The patented SGI NUMAflex architecture makes it possible to scale the number of processors well beyond the level that has been possible in other shared-memory designs. Each processing node has up to four processors and a local pool of up to 8GB of memory. Instead of the traditional backplane design, NUMAflex uses crossbar switches and high-speed cabling, allowing each node direct access to the memory in other nodes with a relatively slight increase in latency versus accesses to local memory (hence the designation NUMA — nonuniform memory access).

NUMAflex uses standard, modular building blocks called bricks that allow systems to scale independently in different dimensions over time, providing unprecedented levels of flexibility, resiliency, and investment protection. Various types of bricks can be added as needed to tailor a system to the exact capabilities required by the application. As an added advantage, SGI® Origin® 3000 systems provide an extremely small physical footprint relative to comparable systems because of the efficient modularity of NUMAflex.

Preparing for the Future

Protection against terrorist threats is critical in the post-9/11 world. ERDC is committed to continue its research to counter these threats. "The question is not if but when," said Dr. Hall. "Additional attacks on U.S. targets are a near certainty. Our research is dedicated to provide the tools that government agencies can use to make the decision between security and strength. Those decisions are now based upon strong experimental evidence and advanced numerical simulation, giving us increased confidence in the results." SGI® supercomputers will continue to play a critical role as ERDC helps the nation prepare for an uncertain future.

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