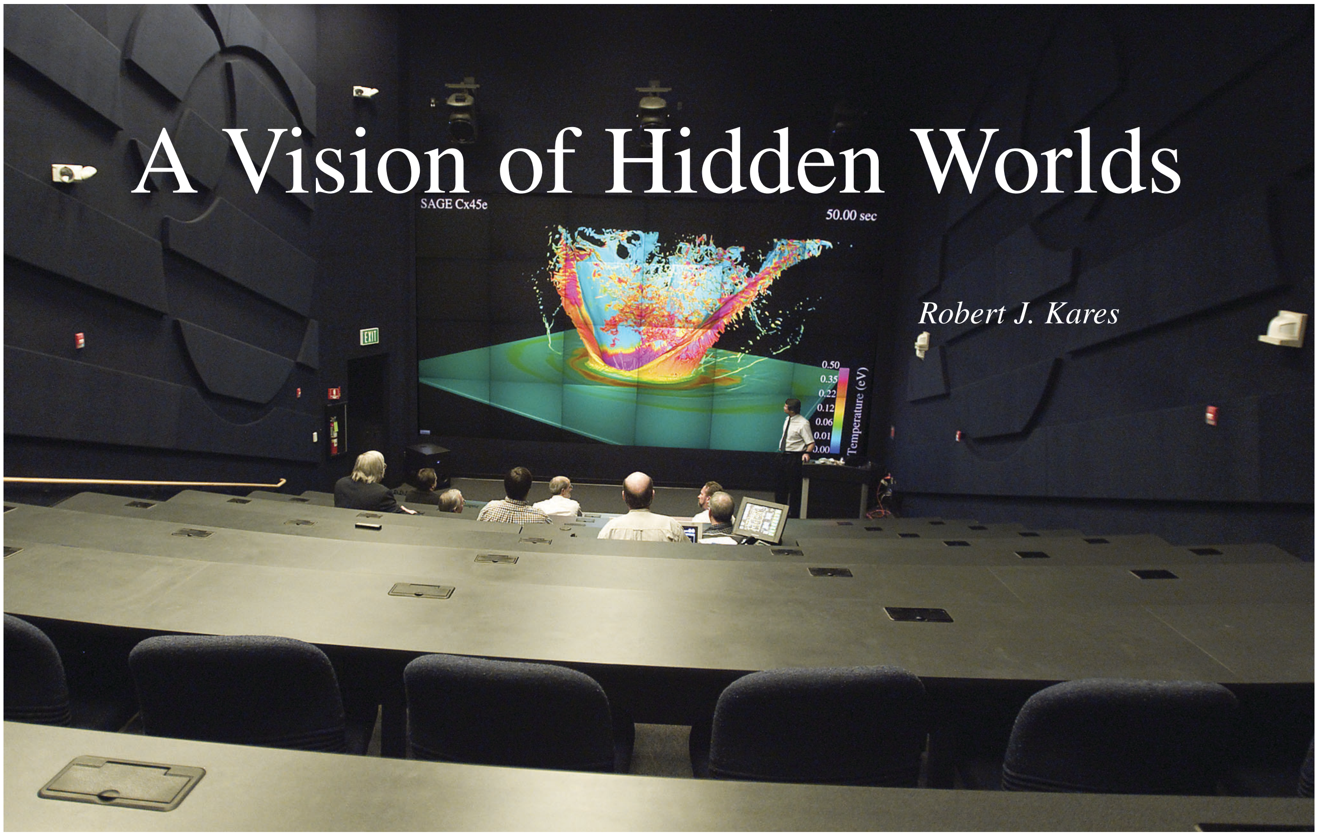
A Vision of Hidden Worlds

Robert J. Kares



The latest in theaters

No human eye will ever see the inside of a nuclear weapon as it explodes. Many important processes in the physical world will never be seen directly by any human eye because they lie too far outside the narrow confines of human existence. However, using the computational power of the Advanced Simulation and Computing (ASCI) program, we have begun to create realistic three-dimensional (3-D) simulation worlds that can be used to study such processes, to bring them into the realm of human experience (see Figure 1). Yet understanding a dynamic, 3-D simulation world whose complexity increasingly approaches that of the real physical world represents a new kind of challenge.

Fortunately, the same tools of perception that human beings use to understand the real world can be applied to simulation worlds. The most important of these tools is human stereo vision. In 1998, the Laboratory began a project called the Visual Interactive Environment for Weapons Simulation (VIEWS), a part of the larger ASCI program, to build an infrastructure that exploits the power of human stereo vision to understand and study the simulation worlds we have created. With this infrastructure, we can now see with our own eyes worlds that could only be imagined by the pioneers who founded the Laboratory 60 years ago.

The visualization infrastructure created by VIEWS is called a Data Visualization Corridor (DVC). A DVC is a very high-performance, end-to-end system of hardware and software that transforms raw simulation data into realistic images and quantitative results that a human user can understand. Large, dedicated visualization server machines read the many terabytes of raw simulation data and produce high-resolution stereo images of the results. These images are then transmitted over a high-bandwidth fiber-optic distribution system to the many viewing facilities of the corridor, which include user desktops, stereo theaters, stereo power-wall displays (see Figure 2), and immersive virtual-reality environments. VIEWS deployed its first DVC in 1998. Today, our latest generation of the DVC provides services for all the many users of the 30-teraflop Q machine in the Laboratory's new Nicholas C. Metropolis Center for Modeling and Simulation (the Metropolis Center).

The principal feature that distinguishes the Los Alamos DVC from a simple, high-end graphics workstation is its ability to manipulate and image truly enormous volumes of data, even when the information does not physi-

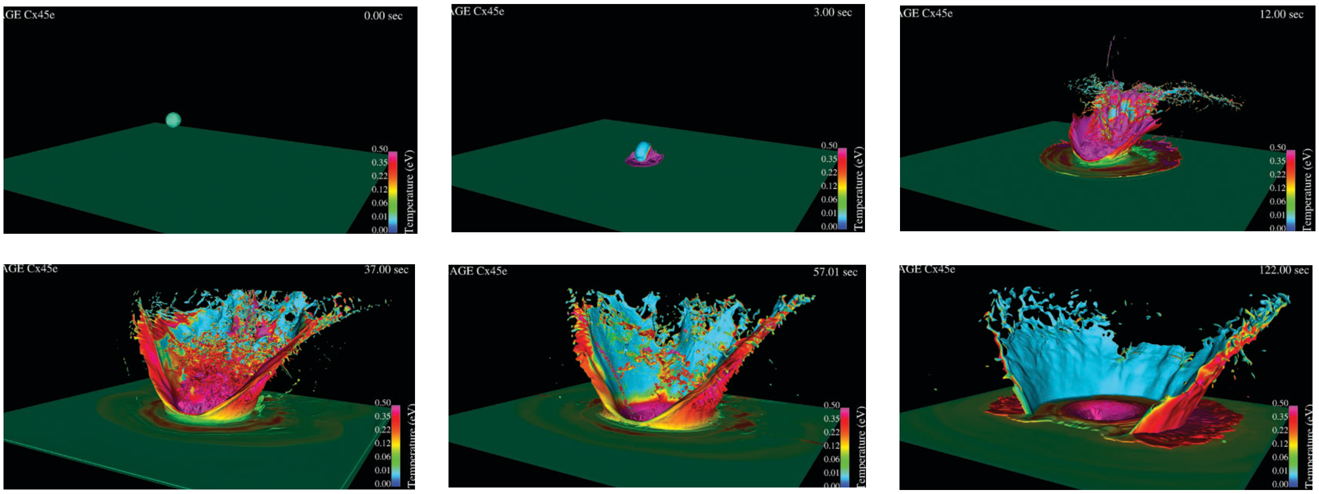


Figure 1. Hidden Worlds
Advanced visualization tools enable us to view the results of extremely large scale simulations with unprecedented realism. The images are from a 3-D simulation of the "dinosaur killer," an asteroid or comet impact event believed to have led to a world-wide sequence of mass extinctions 65 million years ago. Dissipation of the asteroid's 300 teratons TNT equivalent of kinetic energy produced a stupendous explosion that melted and vaporized a substantial volume of calcite, granite, and water and ejected it into the atmosphere in the form of an "ejecta blanket." The measurable distribution of material in the blanket can be used as a diagnostic to determine the direction and angle of impact of the asteroid.

cally reside in Los Alamos. Recently, Laboratory scientists completed a single 3-D simulation on the 12-teraflop ASCI White machine at Lawrence Livermore National Laboratory in California that generated more than 21 terabytes of visualization data. (The entire Library of Congress contains only 17 terabytes of data.) The Los Alamos DVC uses a cluster of three of the largest graphics supercomputers in the world, located in Los Alamos and linked to the Livermore White machine via a high-speed, wide-area network, the DISCOM WAN, to manipulate and image this data interactively.

The video fiber distribution system that carries the images created by these graphics supercomputers to corridor displays contains a 128-way crossbar switch that allows corridor users to switch the graphics output of any of these visualization server machines to any of the viewing facilities on the corridor. The bandwidth of this fiber distribution system is sufficient to display up to 30 high-resolution, stereo color images per second, each image using up to 16 million colors. The corridor can deliver high-resolution color movies of terascale simulation results to users at the same play rate of a normal motion picture. The difference is that corridor movies are fully 3-D stereo movies.

The Los Alamos DVC provides a variety of advanced viewing capabilities for visualization users. At the moment, more than 50 user offices are connected to the corridor. Each office is equipped with a 1920 X, 1200-pixel-resolution, 24-inch, stereo-capable video display, a

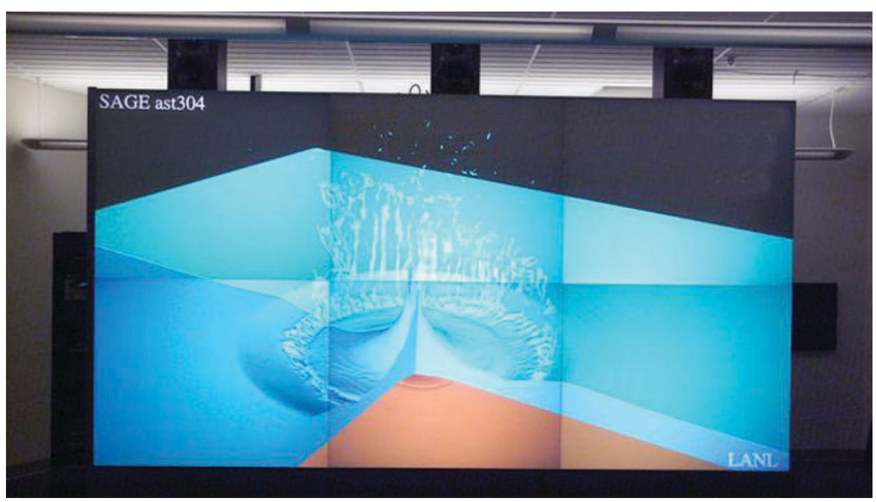


Figure 2. A New Way to View Reality
This illustration shows one of two 8-million-pixel stereo "collaboratory" power walls in the new Metropolis Center. The power wall, which is 11 ft wide by 6 ft high, combines multiple display panels and multiple projectors to create a single large display with very high resolution.

mouse, and a keyboard so that users can interactively view high-resolution stereo images in their offices. The corridor also provides two stereo viewing facilities for the collaboration of small work groups. Each of these "collaboratories" contains an 8-million-pixel stereo power-wall display, such as the one seen in Figure 2.

For larger groups, we have just completed construction of a 31-million-pixel stereo power-wall theater that will provide stadium seating and full 3-D viewing for an audience of 85 people. The power wall for this new theater is 22 feet wide by 12 feet high and uses 24 state-of-the-art Christie Digital projectors arranged in a 6-by-4 matrix to create a single huge stereo display. This theater, which was completed in March 2003, is shown in the photo introducing this article. The theater will allow a large audience full interactive 3-D viewing of terascale ASCI simulations without compromise in image scale or resolution.

The Los Alamos DVC also provides facilities for fully immersive, virtual-reality exploration of large datasets. The first such facility, the Los Alamos Reconfigurable Advanced Visualization Environment (RAVE), was deployed by the Laboratory in 2000. RAVE is a first-generation immersive environment that uses multiple surrounding panels with stereo images to create the illusion that the user is actually inside the virtual world of the simulation. Moving about in real space, one's position is tracked, and one's view is dynamically updated to give the illusion of looking around the hidden corners of real objects. RAVE is a relatively low resolution virtual environment using only about 6.5 million pixels for its images. In 2003, we began construction of our next-generation virtual-reality environment pictured in Figure 3.

This environment will provide a full 43 million pixels of stereo-image resolution. It will also provide both floor and ceiling displays, as well as side displays, so that the user will see the virtual world of the simulation in every direction, even when looking directly up or down. The Los Alamos Digital CAVE will be the most advanced visualization environment in the world and will define the state of the art in virtual reality for years to come.

VIEWS has been very successful in providing the "see and understand" infrastructure so essential to the ASCI mission. Working closely with the rest of ASCI, VIEWS provides a vision of worlds that might otherwise remain forever hidden from human eyes. ■

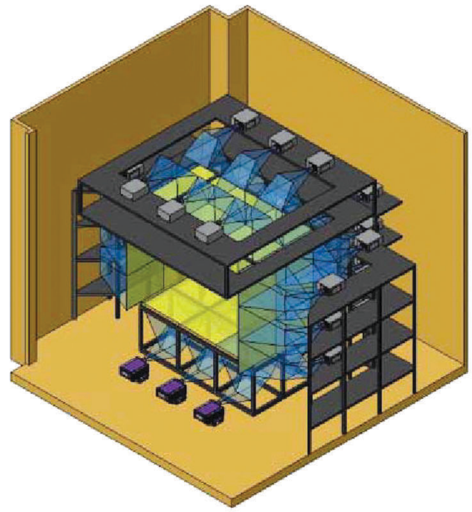


Figure 3. A Glimpse of the Future
This is a sketch of the 43-million-pixel Digital Cave for the Metropolis Center. The Digital Cave is scheduled for completion late in the summer of 2003.

Further Reading

Foley, J. D., and A. Van Dam. 1984. *Fundamentals of Interactive Computer Graphics.* Reading, MA: Addison-Wesley Publishing Company.

Pinker, S., 1997. *How the Mind Works*. New York: W. W. Norton and Company.

Smith, P. H., and J. van Rosendale. 1998. "Data and Visualization Corridors, Report on the 1998 DVC Workshop Series." Center for Advanced Computing Research Technical Report CACR-164, accessible at http://www.cacr.caltech.edu/Publications/DVC, California Institute of Technology, Pasadena, CA.

Robert Kares received his bachelor's degree in physics from the University of Chicago in 1974 and a Ph.D. in physics from the University of California at Irvine in 1982. He joined the technical staff of Applied Physics Division at the Laboratory in 1993 after several years with Thinking Machines Corporation of Cambridge, Massachusetts. He is a computational physicist and one of the founders of the VIEWS project at Los Alamos.