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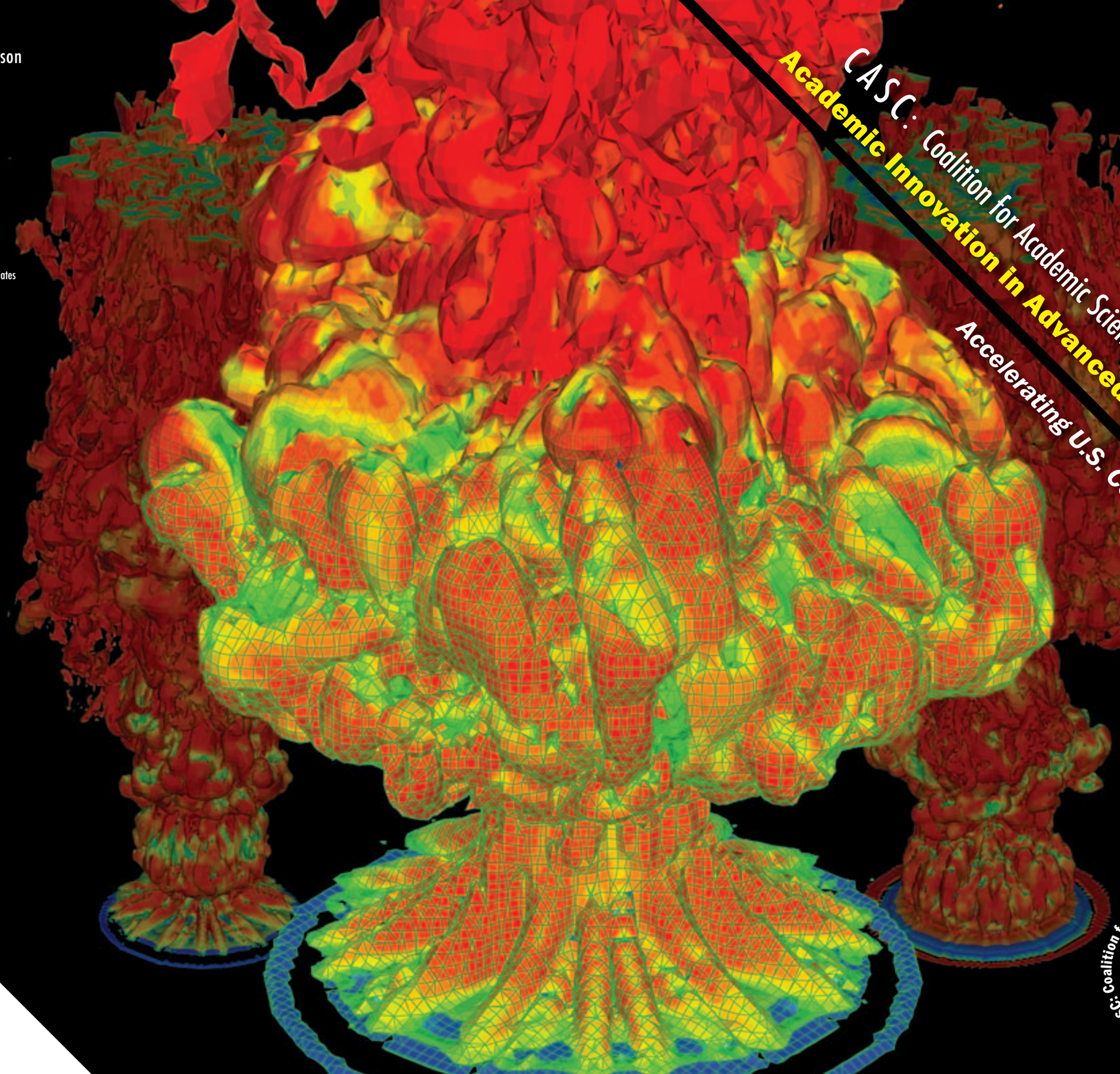

CASC: Coalition for Academic Scientific Computation

Academic Innovation in Advanced Computing

Accelerating U.S. Competitiveness

CASC
Coalition for Academic Scientific Computation
www.casc.org

CASC: Coalition for Academic Scientific Computation
20 Anniversary

Contents

Many people contributed to the success of CASC during its early formative years and the organization benefited immensely from their support. However, lacking a CASC historian, and despite our best effort to acknowledge all early attendees, we may have omitted some participants. Please accept our deepest thanks to one and all.

Jim Almond • Ben Barnes • Jay Blaire • Kathleen Bernard • Jim Bottum • Bill Busbee • Linda Callahan • Beverly Clayton • John Connolly • Larry Conrad • Dan Davis • Dennis Duke • Julio Facelli • Susan Foster • Carolyn Gard • David Grant • Tom Healy • Gary M. Johnson • Mel Kalos • Sid Karin • Ken Kliewer • Larry Lee • Michael Levine • Bill Lewis • Bill McCurdy • Rick McMullen • Walter McRae • Bahram Nassersharif • Pete Peterson • Jim Poole • Dick Pritchard • Louis Proenza • Ron Pugmire • Bill Robinson • David Roselle • Ralph Roskies • David Safford • William Sanders • John Sell • Jim Shankle • Gordon Sherman • Ron Shoenau • Pete Siegel • Larry Smarr • Marty Solomon • John Steele • Joe Thompson • Ray Toland • Ken Tolo • Alicia Towster • Sam Trickey • Joe Yeaton • Julie (Shisler) Van Fleet • Wayne Whitmore • Cliff Woodruff • John Ziebarth

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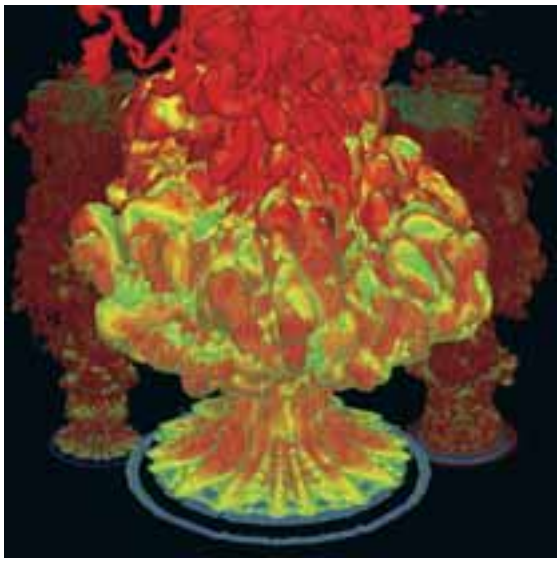
The cover graphic depicts the turbulent instability dynamics of large fire plumes, which have been modeled by Professor Paul DesJardin using Large Eddy Simulation techniques. The simulations were conducted using computers at the University at Buffalo's Center for Computational Research (CCR) and the research is supported through an NSF Career Award. The observed instability dynamics are responsible for the unsteady heat transfer in fire environments and pose one of the greatest challenges to understanding fire. The goal of the research is to develop a better understanding of the turbulent flow for improved predictions of fire intensity and growth. The fire plume image was created using Tecplot software.



CASC Celebrates 20th Anniversary: 1989 – 2009

In 1989 several of our nation's leaders in academic computing were inspired to create an organization that would promote the nation's immense returns on its investments in high end academic computing resources. With a handful of state academic computing centers, they founded the Coalition of Academic Supercomputing Centers (CASC), an educational 501(c)(3) nonprofit organization. Fast-forward 20 years, and CASC is 57 members strong in 32 states representing many of the nation's most forward-thinking universities and computing centers. In many ways, this 20th anniversary brochure is a tribute to those leaders, especially early leaders Charlie Bender and Charles Warlick.

As CASC's membership grew, the emphasis of the organization expanded to include both computing and computation and with that the name officially changed to the Coalition for Academic Scientific Computation (CASC). For 20 years CASC has been at the forefront in advocating the use of the most advanced computing technology to accelerate scientific discovery critical to national competitiveness, global security, and economic success. CASC also promotes advanced technology as an essential tool in the development of a diverse and skilled 21st century workforce to fuel the nation's technological leadership.

The mission of CASC is to:

- disseminate information about the value of high performance computing and advanced communications technologies;
- provide an expert resource for the Executive Office of the President, the Congress, and federal agencies, as well as state and local government bodies; and
- facilitate information exchange within the academic scientific computation and communication communities.

Computational science has become the third pillar of scientific enterprise, a peer with traditional methods of physical experiments and theoretical investigations. Coalition members provide high performance computing (HPC) resources, massive data storage facilities, visualization environments, and software. Connected via high-capacity optical networks, this cyberinfrastructure enables large-scale, long-term, multi-disciplinary networking and information technology R&D, and innovative research at the frontiers of science. By applying advanced technology, CASC members extend the state of the art to achieve scientific, technical and information management breakthroughs beyond imagination, positioning the U.S. at the forefront of the 21st century knowledge economy.

While the world has changed dramatically over the last 20 years, our members remain committed to advancing the nation's research and education enterprise. For 20 years, CASC members have been making computer simulations, advanced analyses, and discoveries possible that were once thought to be impossible, and will continue to do so far into the future.

This brochure provides a snapshot of the research contributions of CASC members – from simulating new pharmaceuticals to modeling climate change, and from detecting brain aneurisms to advancing new energy technologies. More detailed descriptions of each CASC member's contributions to discovery, innovation, and learning are available at: **www.casc.org/members.html**

C A S C

Coalition for Academic Scientific Computation

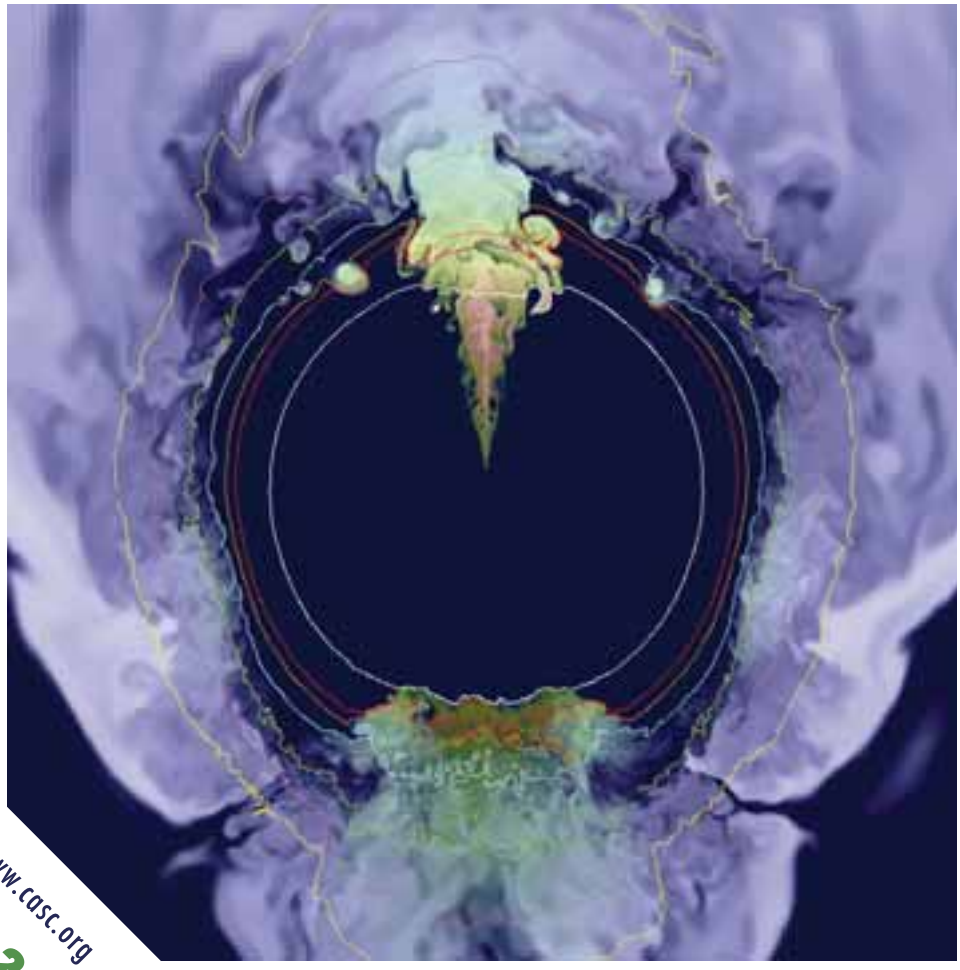
The Evolution of Academic Cyberinfrastructure

"At the startup of The University of Texas (UT) System's Center for High Performance Computing in 1985 the only true network available was ARPAnet. Of the 13 UT institutions, UT Austin was the only UT component connected to it. So we started up using DECnet capabilities and migrated to NSFnet as it became available. We went through a lot of seat-of-the-pants development, but it all came to pass."

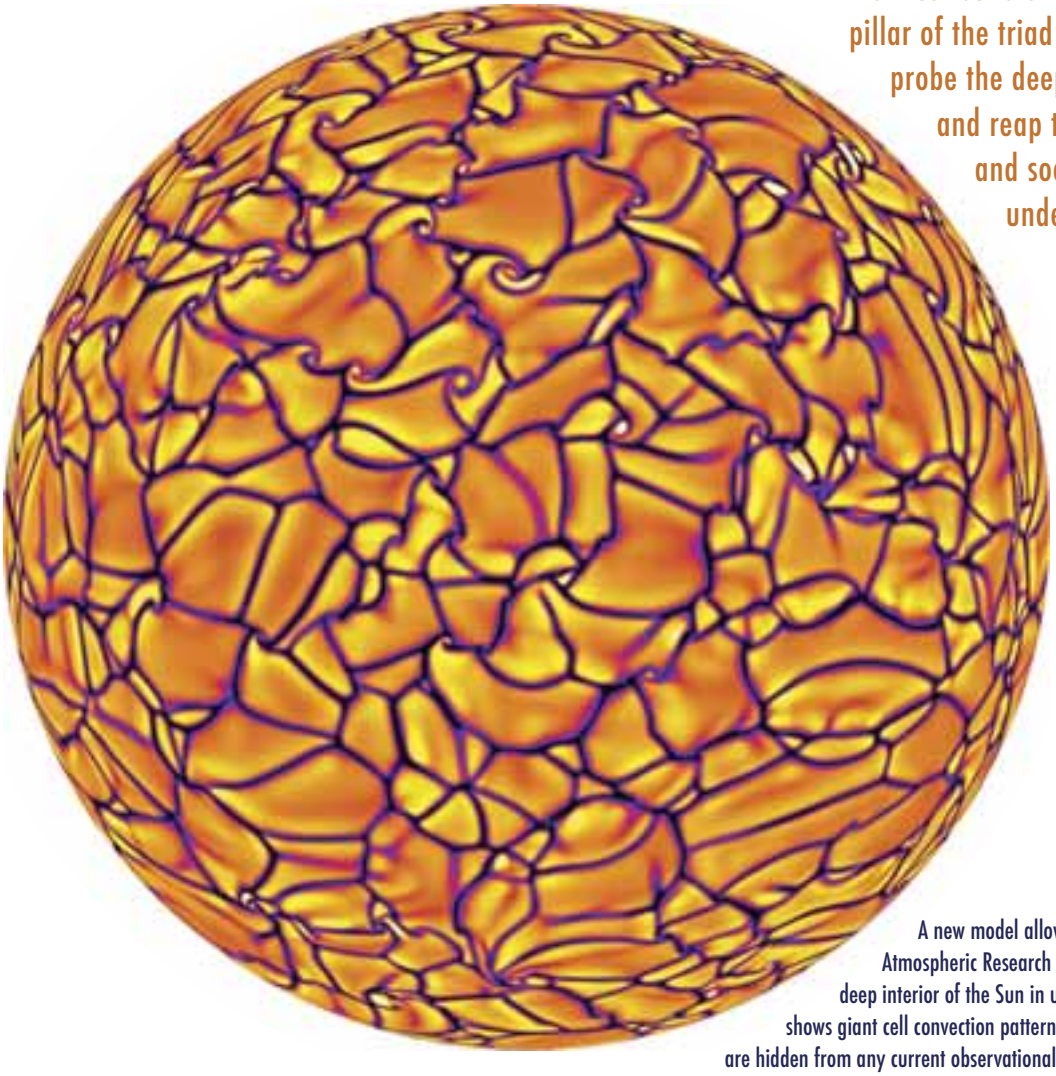
–Charles H. Warlick, retired, The University of Texas System

In the 1960s, the National Science Foundation (NSF) first recognized the need for investments in advanced scientific computation, funding a number of computing centers on university campuses. The NSF made a bold leap forward in the mid 1980s funding the NSF Supercomputer Centers program which operated from 1985 to 1997. The centers were instrumental in pushing the envelope of hardware and software, as well as advancing the frontiers of network infrastructure, leading to further advances in computing and groundbreaking grid projects such as today's TeraGrid and Open Science Grid. Similarly, early, substantial and sustained investments by the Department of Energy (DOE) and the Defense Advanced Research Projects Agency (DARPA) fostered pivotal network research and critical computing capabilities that continue today with the DOE's Advanced Scientific Computing Research (ASCR) program and DARPA's High Productivity Computing Systems program.

CASC members continue to be at the forefront in developing rich information technology environments known as cyberinfrastructure. Cyberinfrastructure is the aggregation of distributed computing systems, data storage systems and repositories, advanced instruments, visualization environments, and people, all linked together by software and advanced networks to improve research productivity and enable breakthroughs not otherwise possible.



With computational resources at the National Energy Research Scientific Computing Center (NERSC) astrophysicists are able to simulate the cross-section of a white dwarf star exploding into a supernova. The lines that form the rings are contours that mark differences in density. The gray tones represent fuel and ash that are enveloping the star. These models are essential to understanding how stars are born, live, and die.



We must build and strengthen the third pillar of the triad of discovery if we are to probe the deepest secrets of Nature and reap the technical, economic, and social benefits such understanding will yield.

–DOE Office of Science, Occasional Paper on the Challenge and Promise of Scientific Computing

A new model allows scientists at the National Center for Atmospheric Research (NCAR) to simulate processes in the deep interior of the Sun in unprecedented detail. The image shows giant cell convection patterns beneath the solar surface, which are hidden from any current observational technique.

In the 20th century the United States competed in the space race. In the 21st century we compete in the knowledge race, which takes place at the speed of light. A powerful cyberinfrastructure fuels the global race for intellectual property and helps find solutions to the most daunting problems facing society today.

CASC members are driving advancements in a range of critical research initiatives – from bioinformatics to healthcare, from nanotechnology to the environment, and from cybersecurity to global security. Moreover, our members are investing in the nation's human capital by building awareness of how information technologies can educate and train citizens, from K-12 students to working professionals. Delivering a better-educated workforce to American industry is imperative to support our nation's competitiveness. A sampling of these initiatives is provided in the sections that follow.

Mechanical engineering students sponsored by the Minnesota Supercomputing Institute (MSI) designed a reconfigurable virtual reality (VR) system for an industry-sponsored, real-world design competition. The students utilized MSI modeling and analysis software to build a 1:3 size scale model of the VR system.

Accelerating the Nation's Research Enterprise

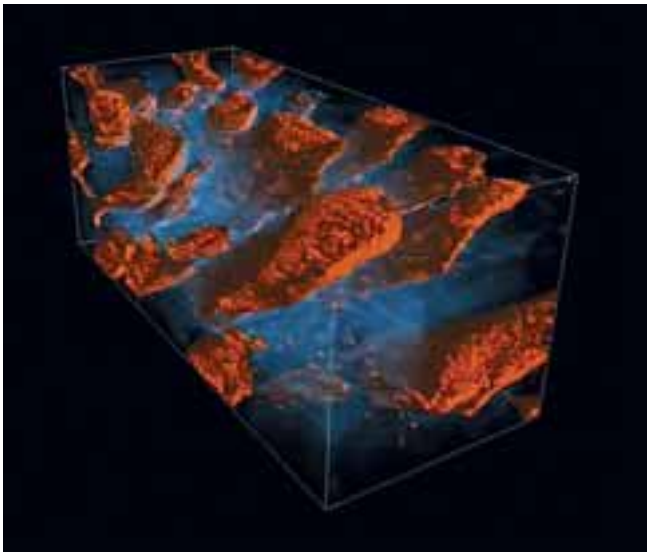
Astronomers have tracked the acceleration patterns and projected the orbits of stars around a mysterious, invisible object at the galactic center, which many researchers believe is a massive black hole. The National Center for Supercomputing Applications (NCSA) created this visualization for a planetarium show and a PBS documentary.

For more than four decades federal investments have accelerated innovation in our nation's scientific computing systems. In 2007, the NSF funded the deployment of the world's most powerful supercomputers – all implemented by CASC members – to further expand the nation's cyberinfrastructure.

- The Texas Advanced Computing Center (TACC) at The University of Texas at Austin and its partners at Arizona State University and Cornell University have deployed *Ranger* – the most powerful supercomputer for open science research in the world at the time of its deployment. *Ranger* has already been upgraded, and now provides the US research community with over 579 teraflops of processing capability, and a world-class team of experts supporting its use.
- The National Institute for Computational Sciences (operated by a partnership of the University of Tennessee at Knoxville Joint Institute for Computational Science and its partners at Oak Ridge National Laboratory, TACC, and the National Center for Atmospheric Research) is engaged in a five-year project to acquire and deploy *Kraken*, an extremely powerful new system with a peak performance of nearly one petaflop.
- The National Center for Supercomputing Applications (NCSA), IBM, and partners will build the world's first computational system capable of achieving sustained multi-petaflop performance, dedicated to open scientific research. This system, named *Blue Waters*, is expected to go online in 2011.

In 2008, the National Science Board (NSB) approved an award of a new petaflop system to another CASC member – the Pittsburgh Supercomputing Center (at this time the details of the proposed system are unavailable).

In 2005, for the first time, forecasts correctly predicted the details of thunderstorms 24 hours in advance. Using resources at the Pittsburgh Supercomputing Center, a computer forecast by the Center for Analysis and Prediction of Storms predicted a storm line moving from Kansas into Missouri extending into Iowa. This graphic shows radar reflectivity (increasing from blue through red), which is proportional to precipitation intensity.



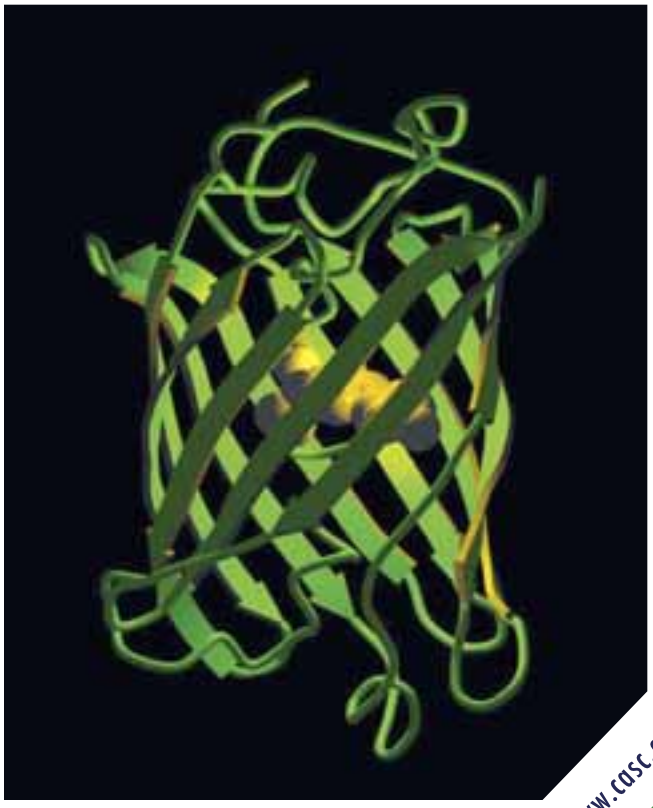
New imaging capabilities accelerate medical research and treatments. This 3D image shows part of the heart muscle cell and was simulated on the Maverick system at the Texas Advanced Computing Center. The red objects are mitochondria, the "power house" of the cell.

The projects below are representative of the forward-thinking, national cyberinfrastructure initiatives in which CASC members play a significant leadership role.

- NSF's TeraGrid is the world's largest distributed cyberinfrastructure for open scientific discovery, involving eleven resource partner sites. Using ultra high-performance network connections, the TeraGrid integrates leadership-class computers, data resources and tools, and high-end experimental facilities. It currently supports more than 1,000 projects and over 4,000 researchers geographically spanning the entire United States.
- The National Center for Microscopy and Imaging Research (NCMIR) is a premier example of how cyberinfrastructure advances biomedical science. Using state-of-the-art 3D imaging and analysis technologies developed by NCMIR, researchers around the world collaboratively access rare high-energy electron microscopes and powerful information technology resources via optical networks. Funded by the National Institutes of Health (NIH), NCMIR advances scientific inquiry leading to new discoveries and potential treatments for human neurological disorders.
- The Open Science Grid (OSG) is working to satisfy the ever-growing computing and data management requirements of scientific researchers, especially collaborative science requiring high-throughput computing. Participating research communities gain low-threshold access to a greater number of resources than they could individually afford. OSG is a consortium of software, service and resource providers, as well as researchers, many participating from CASC member sites. Funded by the NSF and DOE, OSG resources are forging new discoveries to improve understanding of the very essence of matter.

Supercomputers have so greatly transformed the conduct of scientific work that many physicists and chemists speak of computational science as an intellectual revolution equal in impact to the observational paradigm of Galileo and the theoretical insight of Newton.

–The National Challenge in Computer Science and Technology, National Research Council, 1988



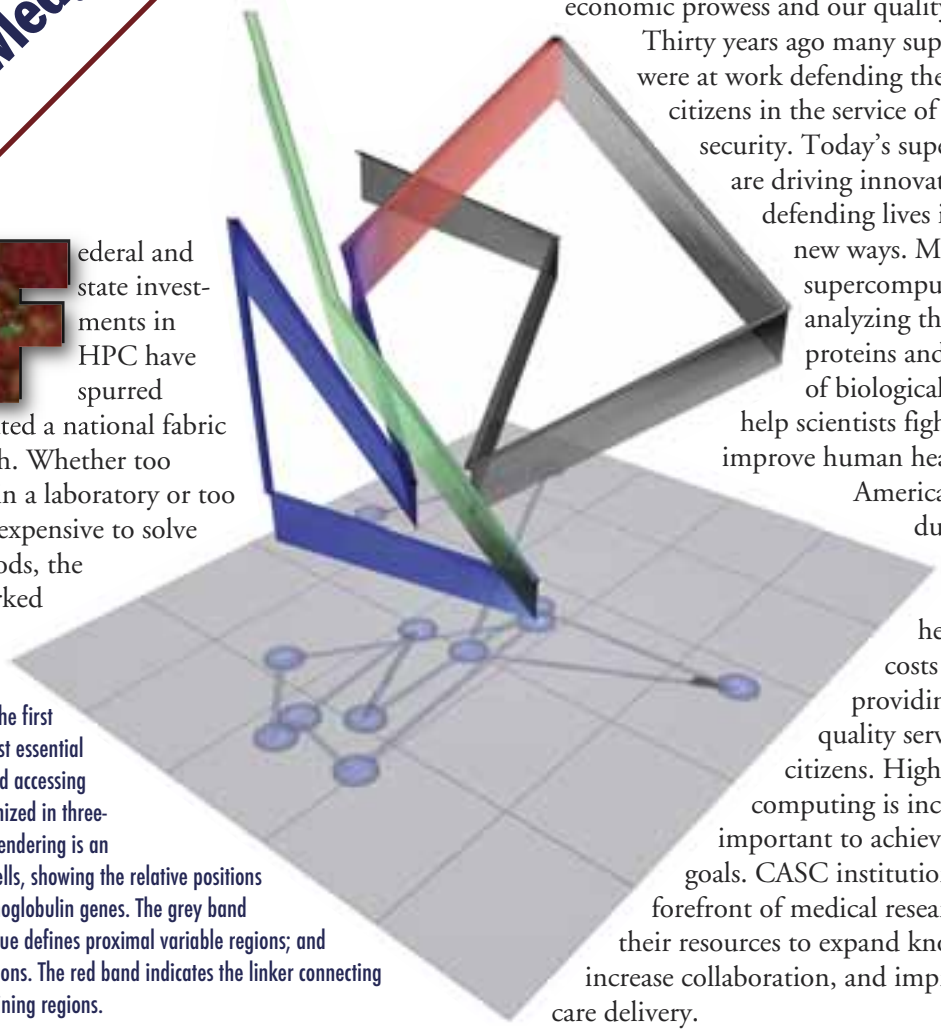
Roger Tsien, UCSD researcher and NCMIR co-principal investigator, shared the 2008 Nobel Prize in Chemistry for his development work in expanding the use of the green fluorescent protein (GFP) found in jellyfish. Fluorescent proteins are powerful tools enabling scientists to quickly see with great clarity real-time interaction of molecules in living cells. The ability to observe previously invisible processes and functions promises new insights into the development of nerve cell damage and cancer cell growth.

Driving Discovery and New Knowledge

Federal and state investments in HPC have spurred innovation and created a national fabric to accelerate research. Whether too hazardous to study in a laboratory or too time consuming or expensive to solve by traditional methods, the nation's rich networked information technology infrastructure is enabling the multi-disciplinary, collaborative research that leads to rapid and systematic advancements for the nation's economic prowess and our quality of life.

Thirty years ago many supercomputers were at work defending the lives of citizens in the service of national security. Today's supercomputers are driving innovation and defending lives in entirely new ways. Modern supercomputers are analyzing the structure of proteins and the function of biological pathways to help scientists fight disease and improve human health.

America faces the dual challenge of reducing national health care costs while providing affordable, quality services for its citizens. High performance computing is increasingly important to achieving both goals. CASC institutions are at the forefront of medical research, using their resources to expand knowledge, increase collaboration, and improve health care delivery.



SDSC and UC San Diego researchers have shown for the first time how a genome - the most essential part of the cell for storing and accessing genetic information - is organized in three-dimensional space. This 3D rendering is an immunoglobulin locus in B cells, showing the relative positions of various portions of immunoglobulin genes. The grey band indicates constant regions; blue defines proximal variable regions; and green are distal variable regions. The red band indicates the linker connecting the proximal variable and joining regions.

While the United States clearly is the global NIT [Networking and Information Technology] leader today, we face aggressive challenges from a growing list of competitors. To maintain – and extend – the Nation's competitive advantages, we must further improve the U.S. NIT ecosystem – the fabric made up of high-quality research and education institutions, an entrepreneurial culture, strong capital markets, commercialization pathways, and a skilled NIT workforce that fuels our technological leadership.

–President's Council of Advisors on Science and Technology, 2007

Earth scientists at Rice University perform three dimensional simulations of convection in the Earth's mantle. The image shows temperature isosurfaces – warm colors represent hot material and cold colors represent cold material – of a very long convection cell. This flow pattern is a consequence of flow channelization in the asthenosphere, a region of low viscosity in the upper few hundred kilometers of Earth's mantle.

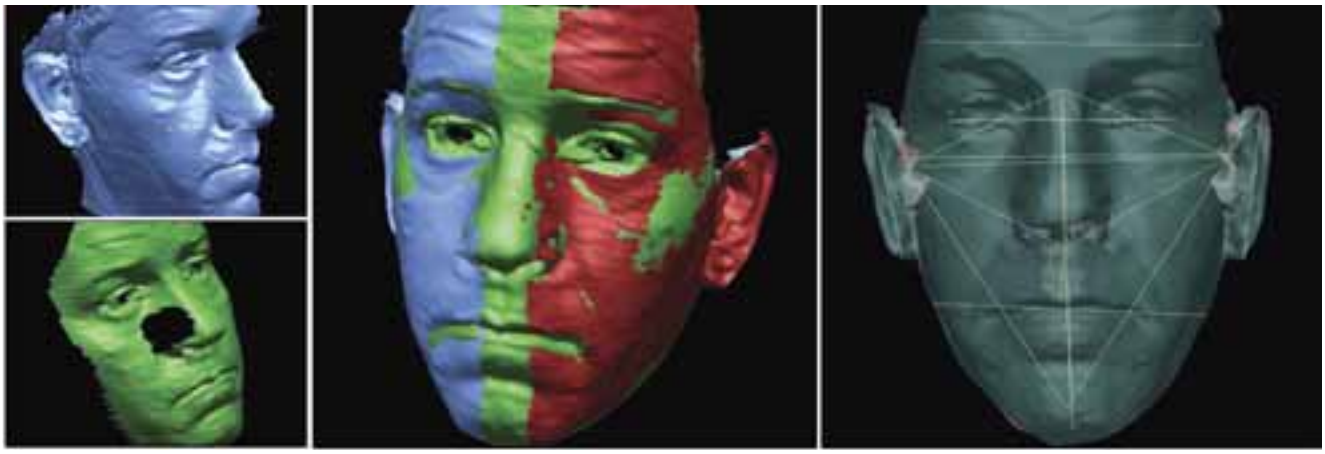
"U.S. leadership is indeed under challenge in many ways across the globe. As regards networking and information technology, these challenges are unprecedented. Without strong investment in NIT, the U.S. is at risk of losing its long-standing position of global leadership...However, the recommendations made in the PCAST report, if enacted into legislation and well funded, will continue and extend U.S. leadership in network and information technology, and will fuel future U.S. global leadership in innovation."

–Testimony of Craig A. Stewart, CASC Chair 2007-2008, before the Committee on Science and Technology, U.S. House of Representatives, 2008

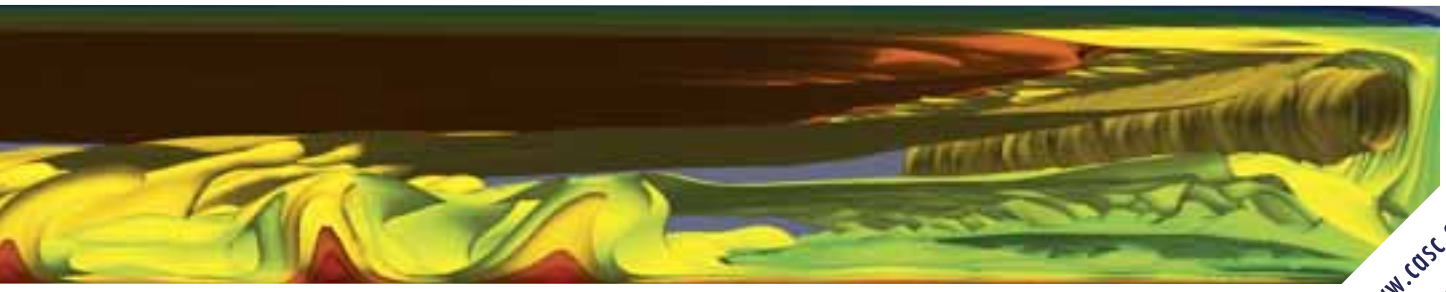
As a result, medical providers routinely employ high bandwidth networks for real-time, remote diagnostics. Federal support for research that applies advanced computer technology to health care delivery is proving a sound investment.

Scientists working to predict severe weather have one simple goal: to determine the likely occurrence and path of tornadoes and hurricanes quickly and accurately enough for people in affected areas to get out of harm's way. CASC members are hard at work improving the capabilities of weather models, expanding the capabilities of the supercomputers and grid computing systems to make real time predictions and saving lives.

Volcanic ash particulates cause serious health problems as well as create dangerous flying conditions for jet aircraft. While ash clouds look the same as normal clouds – particularly to pilots – the tiny, razor-sharp volcanic particles can cause an immediate engine shutdown. Using the Weather Research and Forecasting model run at the Arctic Research Supercomputing Center improves high-resolution forecasts predicting volcanic ash cloud location, altitude and pattern.



The collaborative initiative on Fetal Alcohol Spectrum Disorder (FASD) is an NIH-funded initiative to inform and develop effective interventions and treatment approaches for FASD. Indiana University (IU) is leading the multidisciplinary research team of 15 institutions around the world. The image illustrates a portion of the acquisition and processing pipeline using a volunteer control subject (i.e., a non-FASD patient.) Hundreds of facial scans are being acquired at multiple international sites and are being securely transferred, stored, processed, and analyzed with the help of advanced cyberinfrastructure. Researchers are looking to make significant improvements in the sensitivity and accuracy of diagnosis techniques, ultimately leading to more targetted treatments and improved quality of life for patients and their families.



Data, Data Everywhere

This is a Paraview visualization of Pointe du Hoc, France, site of one of the more important battles of D-Day. The area was captured through a synthesis of laser scanning and digital images. This visualization assists the study of water and wind erosion and is part of the American Battle Monuments Commission's project to preserve this and other historic sites.

Today most new information is 'born digital,' which results in a data deluge for researchers and businesses alike. The overwhelming masses of digital data being generated via network-connected devices are now a critical data-management problem. Creating new tools vital to collecting, organizing, analyzing, storing, and reusing data is a high priority for CASC members. Powerful science gateways provide a logical interface for scientists to access supercomputers and data storage resources required to support today's leading-edge scientific discovery and innovation.

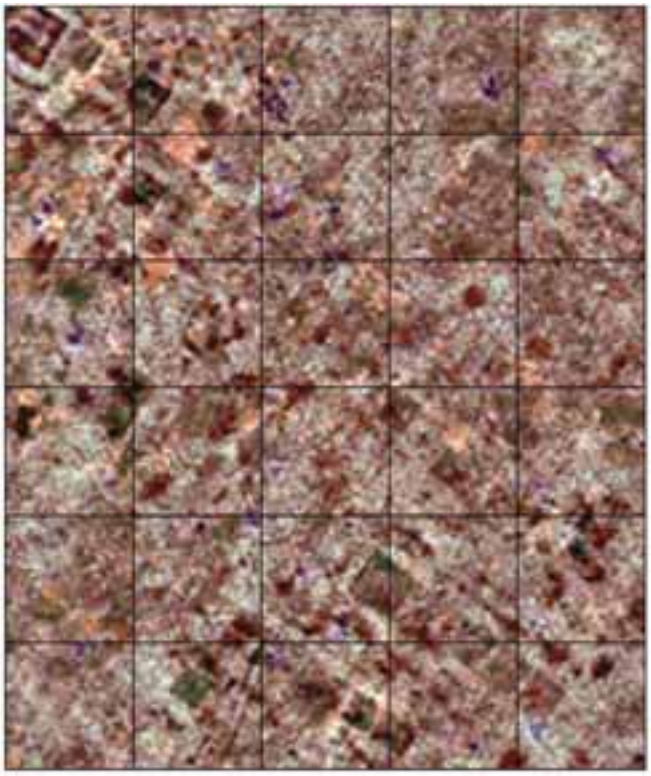
Many CASC members are leading the way in the development of the next generation of data management tools that are changing the way multi-investigator, multi-disciplinary research teams manage and understand the next tidal wave of data. Several federal programs are supporting the development of tools and technology to help address the variety of challenges that arise in managing these massive data sets.

The new NSF Sustainable Digital Data Preservation and Access Network (DataNet) initiative aims to build a sustainable infrastructure – one that is open, extensible, and evolvable. Creating such a digital data framework is essential for preservation and access to the resources and products of our networked digital future through their entire data life cycle.

Istanbul, which lies just north of the North Anatolian fault, is at high risk for a major earthquake within the next 30 years. The Metropolitan Municipality of Istanbul is planning the development of an entirely new satellite city. Visualizing the proposed city using the Purdue teraDRE/Condor pool presented many challenges because of its complexity and the scale of the area to be visualized (an area of 40,000 acres that will eventually be home to 1.5 million residents).

[I]n a world saturated with information and with the tools to effectively get it and process it, we are entering a new era where IT is the major driver of progress and change in many areas of our lives and society.

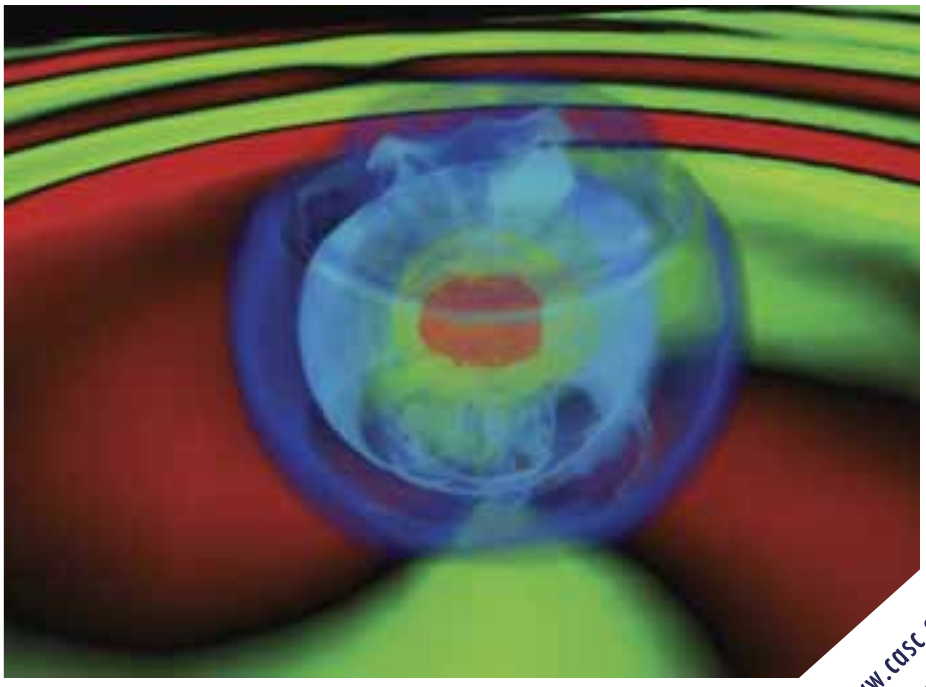
–The Information Technology and Innovation Foundation report, Digital Quality of Life report, 2008



This image, produced by archaeologists at the University of Arkansas' Archeo-Imaging Lab and the Center for Advanced Spatial Technologies, is a fusion of three geophysical datasets showing the buried ruins of an 800-year-old prehistoric village in modern-day New Mexico. The individual datasets reveal different components of the village, including rectangular and circular pit-house foundations, fire pits for cooking and heating, and extensive patio surfaces. When displayed together they create a detailed map of what lies beneath today's desert floor.

With NSF funding, biologists are launching the first global cyberinfrastructure center known as iPlant. iPlant catalogues and leverages the resources and data generated through the National Plant Genome Initiative. One feature of iPlant is the ability to map the full expanse of plant biology research in much the way commodity browsers utilize mapping technology. Users of iPlant may one day be able to "zoom" in and out among various levels of plant biology, from molecules to organisms to ecosystems. With this advanced data tool, a researcher might "zoom in" to analyze the carbon fixed, oxygen produced, and water utilized by individual leaves, then "zoom out" to analyze how all of these might effect large-scale changes in ecosystems and how that could in turn affect air quality and climate.

While managing large complex data sets is a well-known challenge in the hard sciences, it is also a significant challenge among scholars from the social sciences and humanities. For example, the Sloan Digital Sky Survey (SDSS) – which includes millions of x-ray, infrared, and visible light images of over a hundred million celestial objects – requires over 40 terabytes of information. In comparison, the Shoah Foundation Institute's Visual History Archive is a compilation of 52,000 videotaped interviews of Holocaust survivors and other witnesses collected in 32 languages from 56 countries. A digital copy of the archive created by the Institute for general access uses over 175 terabytes of online storage.



Researchers from the Louisiana State University Center for Computation & Technology are collaborating with Caltech, the Albert-Einstein-Institut, the Zuse Institute and Stanford to further understanding of rapidly collapsing stars and gravitational waves. Researchers use these visualizations to prove the last part of Einstein's Theory of Relativity.

Sustaining the Nation's Competitive Edge

The ability of U.S. firms to compete in world markets depends critically on their ability to continually generate new ideas and use new technologies. To remain competitive, the United States must remain at the cutting edge of science and technology and adopt and implement the new technology developed.

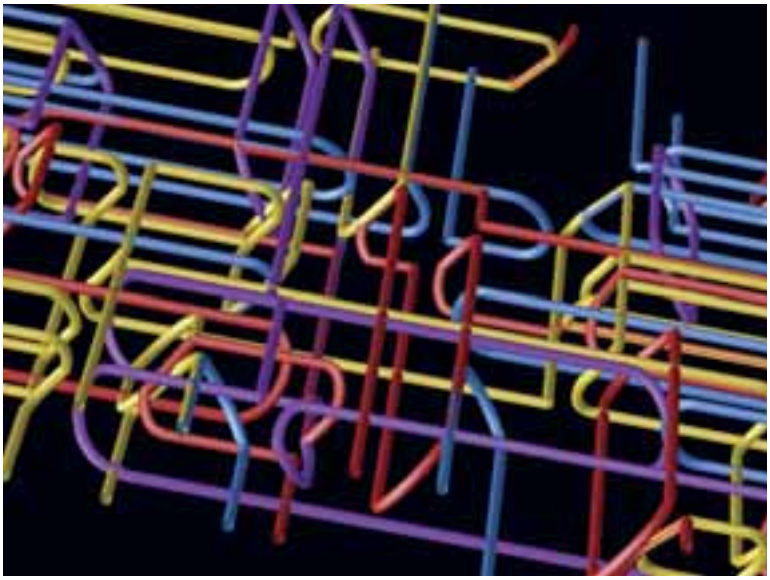
–The Role of Science and Technology in Economic Competitiveness,
The Conference Board and the National Governors Association, 1988

High performance computing is one of America's greatest competitive strengths. It provides unique opportunities for scientific breakthroughs, allowing industry to maintain an edge in R&D, to pursue "high-risk, high-payoff" ideas, and to speed proof-of-concept of new products to the global marketplace.

For more than two decades, CASC member universities and centers have been the core of our nation's research enterprise. Both the NSF and the DOE encourage their advanced computing centers to collaborate with industry, supporting the research enterprise, and stimulating the use of advanced computing in the private sector. The DOE's Innovative and Novel Computational Impact on Theory and Experiment (INCITE) program is a remarkable example of this type of collaboration: INCITE invites academic and industrial researchers to perform computationally-intensive, large-scale research projects on DOE systems. And while the NSF partnerships are created on an ad-hoc basis, they are similarly helping to sustain leadership in the evolution of networking, information and communications technologies, as well as spurring innovation and productivity across all sectors.

Whether a micro-cap or blue chip company, our industrial partners are reducing the time and effort required to bring a product to market by tapping into the cutting-edge computational resources as well as the scientific and technical expertise of CASC members. As strategic partners we are working to ensure that the United States remains the world's premier place for innovation, to create high-paying jobs and a comfortable standard of living, as well as increased security for our citizens.

Industry, faculty and student representatives participated in the Utah Advanced Computing Summer Institute. The institute was organized by the Utah Cyberinfrastructure Consortium, the Utah Science Technology and Research initiative and the Utah System of Higher Education.



Engineers and material scientists are studying the behavior of defects in thin metal films using high-performance computing clusters at the Cornell Center for Advanced Computing. Thin metal films are critical components of many high-tech devices. They form the microscopic conducting wires in integrated circuits; act as optical reflecting or absorbing layers in cameras, photocopiers, and lasers; and, are used for chemical activation in catalytic converters.

Inspiring the Next Generation of IT Professionals

Today CASC members are accelerating the capacity of supercomputers, networks, and software for the next generation of America's IT ecosystem. In addition, we are also developing the workforce of tomorrow to utilize, program and administer *their* cyberinfrastructure.

Our members are actively engaged in education, outreach and training programs designed to increase the number of students pursuing advanced degrees in computer science and engineering. And, we're training students in the multi-disciplinary teamwork needed to solve complex, real-world problems. Our members are leading programs designed to broaden the participation of new communities to ensure that America's best and brightest includes minorities and women who are contributing to and reaping the benefits of the 21st century knowledge economy.

CASC member outreach programs start at the elementary school level and continue through graduate education and lifelong learning for established professionals.

Students attending the Grace Hopper Celebration of Women in Computing 2007 and the Richard Tapia Celebration in Diversity Conference 2007 participated in a Bridge Day (between the two conferences) activity – a behind-the-scenes tour of Disney World. Here they are learning how Disney's security system works. CASC members help to provide students with a community of support as they pursue their degrees.

"It is of great importance that the general public be given an opportunity to experience – consciously and intelligently – the efforts and results of scientific research... Restricting the body of knowledge to a small group deadens the philosophical spirit of a people and leads to spiritual poverty."

–Albert Einstein

The Empowering Leadership (EL) Alliance, supported with funding from the NSF, is an innovative program that connects minority computer science students at Tier 1 universities to prepare them for future success. These students from CASC member UT Austin attended the 2007 Richard Tapia Celebration of Diversity in Computing conference where hundreds of minority students had the opportunity to interact with many CASC members.

Elizabeth City State University (ECSU) collaborates with multiple CASC members in cyberinfrastructure supporting polar ice sheet research. ECSU student Je'aime Powell was part of a team of technologists that deployed computer systems for data management in Greenland. "I love telling people I'm going out to save the world," said Je'aime.

Accelerating the Agenda of the U.S. Federal and State Governments

CASC members develop partnerships with federal and state government entities as well as private industry leaders to contribute to strategic national goals. A representative list appears below:

U.S. Federal Government

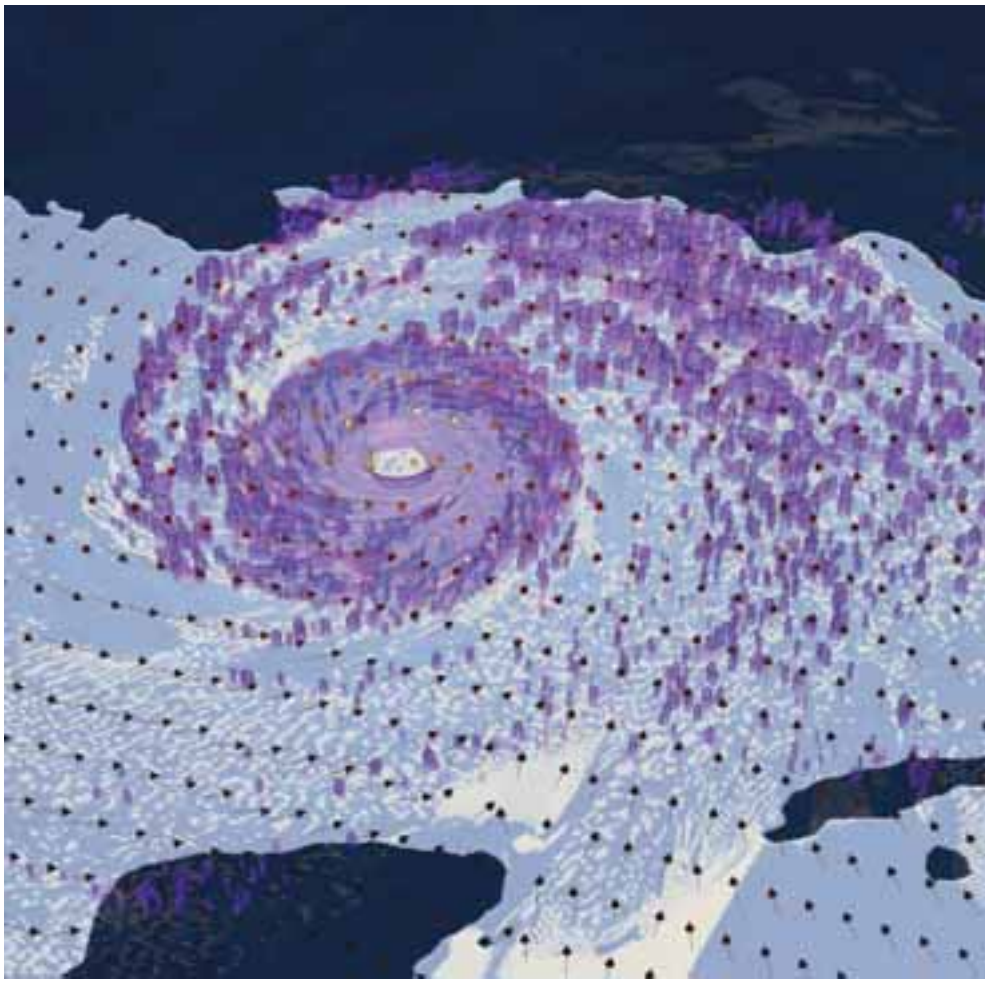
Department of Commerce
National Oceanic and Atmospheric Administration
Department of Defense
Department of Education
Department of Energy
Department of Homeland Security
Environmental Protection Agency
National Aeronautics and Space Administration
National Institutes of Health
National Library of Medicine
National Science Foundation

Federal Advisory Committees

NSF Computer Information Sciences and Engineering Advisory Committee
NSF Office of Cyberinfrastructure Advisory Panel
President's Council of Advisors on Science and Technology

The model of progress through partnerships between the public and private sectors – in the case of supercomputing, federal leadership with state, university and corporate cooperation – must be retained and improved.

–Supercomputing for the 1990s: A Shared Responsibility
Higher Education and Technology Committee of the National Association of State Universities and Land Grant Colleges, 1989



A research team from North Carolina State University and the Renaissance Computing Institute collaborated to create this visualization of Hurricane Katrina at 2 kilometer grid resolution using the Weather Research Forecasting (WRF) model. The image shows rain isosurfaces with the purple areas being the areas with the heaviest rainfall. Dark blue areas are land masses.

CASC Members

Advanced Research Computing (ARC), Virginia Tech, Blacksburg, VA

Advanced Scientific Computation Center (ASCC), Northeastern University, Boston, MA

Arctic Region Supercomputing Center (ARSC), Fairbanks, AK

Arizona State University, Tempe, AZ

Army High Performance Computing Center, Reston, VA

Boston University Center for Computational Science, Boston, MA

Center for Advanced Academic Computing, University of Michigan, Ann Arbor, MI

Center for Advanced Computing Research, California Institute of Technology, Pasadena, CA

Center for Computation & Technology (CCT), Louisiana State University, Baton Rouge, LA

Center for Computational Research, University at Buffalo, Buffalo, NY

Center for Computational Sciences, University of Kentucky, Lexington, KY

Center for High Performance Computing, University of New Mexico, Albuquerque, NM

Center for High Performance Computing, University of Utah, Salt Lake City, UT

Center for High Performance Computing, HPC@USC, Utah State University, Logan, UT

Clemson Computing and Information Technology (CCIT), Clemson, SC

Core Facility in Advanced Research Computing, Case Western University, Cleveland, OH

Cornell University Center for Advanced Computing, Ithaca, NY

CUNY High Performance Computing, Staten Island, NY

East Carolina University, Greeneville, NC

Florida State University School of Computational Science and Information Technology, Tallahassee, FL

Georgetown University's Advanced Research Computing (ARC), Washington, DC

Georgia Institute of Technology, Atlanta, GA

High Performance Computing Center, Michigan State University, East Lansing, MI

High Performance Computing Center, Texas Tech University, Lubbock, TX

Indiana University, Bloomington and Indianapolis, IN

Ken Kennedy Institute for Information Technology (K2I), Rice University, Houston, TX

Lawrence Berkeley National Laboratory, Berkeley, CA

Maui High Performance Computing Center, University of Hawaii, Honolulu, HI

Minnesota Supercomputing Institute, University of Minnesota, Minneapolis, MN

Mississippi State University, Mississippi State, MS

National Center for Atmospheric Research (NCAR), Boulder, CO

National Center for Supercomputing Applications (NCSA), Champaign, IL

National Institute for Computational Sciences (NICS), University of Tennessee, Knoxville, TN

National Supercomputing Center for Energy and the Environment (NSCEE), University of Nevada, Las Vegas, NV

NDSU Center for High Performance Computing, North Dakota State University, Fargo, ND

Oak Ridge National Laboratory Center for Computational Sciences, Oak Ridge, TN

Ohio Supercomputer Center, Columbus, OH

OU Supercomputing Center for Education and Research, University of Oklahoma, Norman, OK

Pacific Northwest National Laboratory (PNNL), Richland, WA

Pennsylvania State University, University Park, PA

Pittsburgh Supercomputing Center, Pittsburgh, PA

Princeton University, Princeton, NJ

Purdue University, West Lafayette, IN

Renaissance Computing Institute, University of North Carolina, Chapel Hill, NC

San Diego Supercomputer Center, La Jolla, CA

Scientific Computation Research Center (SCOREC), Rensselaer Polytechnic Institute, Troy, NY

Texas A&M University Institute for Scientific Computation, College Station, TX

Texas Advanced Computing Center (TACC), The University of Texas at Austin, Austin, TX

Texas Learning and Computation Center, The University of Houston, Houston, TX

University of Arkansas, Fayetteville, AR

University of Florida, Gainesville, FL

University of Iowa, Iowa City, IA

University of Louisville, Louisville, KY

University of Miami, Miami, FL

University of Nebraska, Omaha, NE

University of South Florida Research Computing, Tampa, FL

University of Southern California Information Sciences Institute, Marina del Rey, CA

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–Supercomputers: Government Plans and Policies
Office of Technology Assessment, United States Congress, 1988