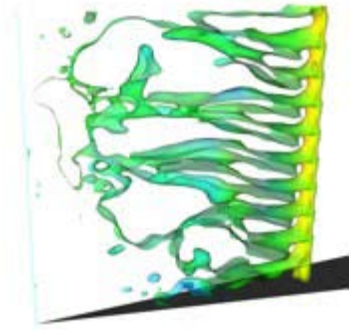
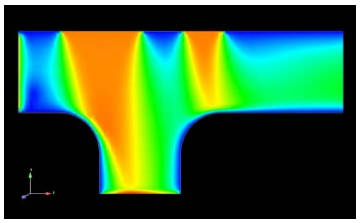
Innovation at the Interface of Science and Engineering:

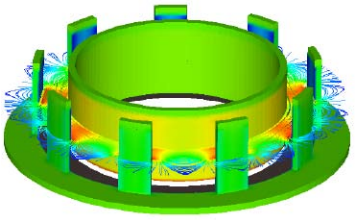
The Capability Advantage

SANDIA NATIONAL LABORATORIES
High-Performance Computing

Sandia has a long and distinguished history in massively parallel computing.







State-of-the-Art Computational Science Applications: (top) Understanding plasma instabilities is a critical element in achieving fusion in the laboratory. (middle) The detailed behavior of semiconductor material when insulted with radiation is required to predict the survivability of satellites and weapon systems. (bottom) Simulation is being used to optimize the magnetohydrodynamic drive of pulse power systems.

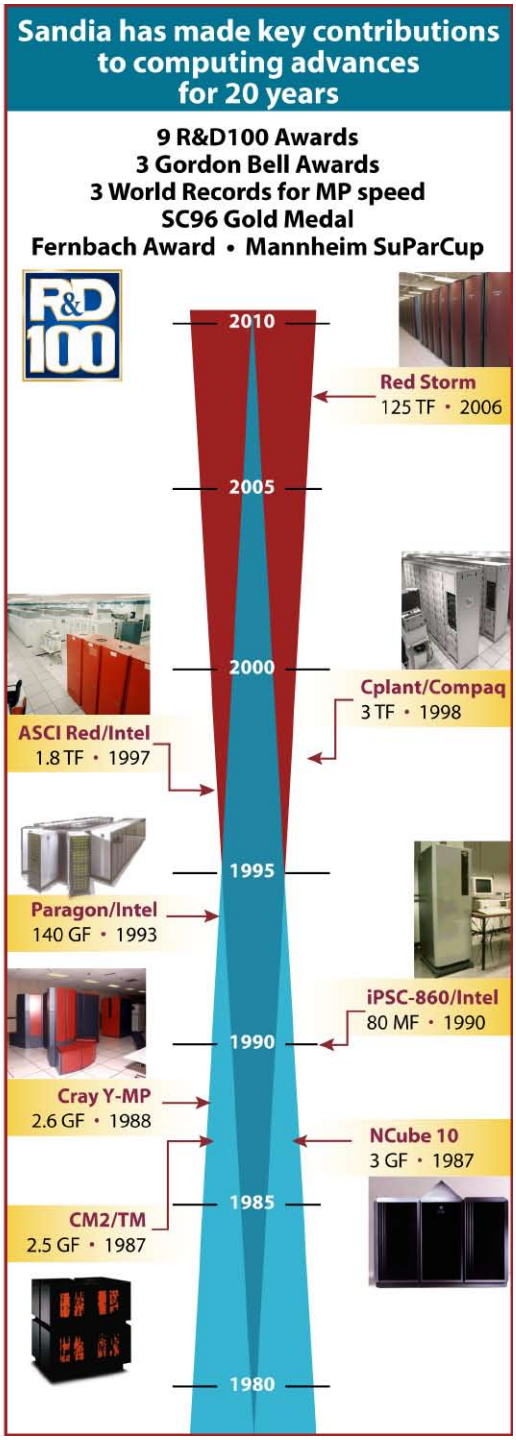
Sandia's Parallel Computing History

Sandia has a long and distinguished history in massively parallel computing. In 1987 Sandia won the inaugural Gordon Bell Prize and the Karp Challenge for showing that scientific applications could achieve thousand-fold speedups on Massively Parallel Processors (MPPs). In the late 1980s Sandia was the first national laboratory to transition all of its computing from vector supercomputers to MPPs. Since then Sandia computational scientists have won two more Gordon Bell Prizes, numerous R&D100 awards, and the Mannheim SuperCup. A Sandia partnership with Intel resulted in several world records for computational speed and the development of the world's first Teraflops supercomputer in 1997 (ASCI Red).

Sandia's work in high-performance computing (HPC) has been paramount to the success of Advanced Simulation & Computing (ASC) at all three NNSA laboratories.

Distinguishing impacts include:

- Extremely broad set of applications ranging from materials science to mechanical response and high-energy density physics to electrical system response
- Lightweight kernel technology that formed the basis for the operating systems on the Intel Paragon, the Intel Teraflops supercomputer (ASCI Red), and Cray's XT3
- Key mathematical libraries that are used by the tri-lab HPC community (Trilinos for solving systems of equations; Zoltan for load balancing; and Dakota for optimization)



Sandia National Laboratories

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000. SAND 2007-6801P

National Nuclear Security Administration

10/2007

Sandia's Red Storm: The design of Red Storm facilitates cost-effective upgrades to more than 30 times beyond the serial #1 platform and has provided the foundation for the DOE Office of Science Leadership Class Petaflop computer at Oak Ridge National Laboratory. Presently, there are 36 Red Storm installations at 20 sites.

Red Storm : Balanced Performance + Time Critical Applications = Commercial Success

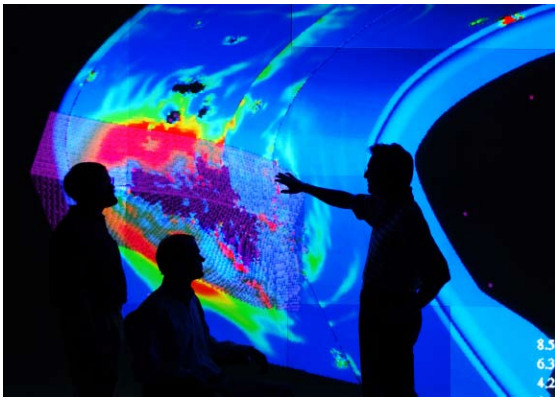
In addition, Sandia and Cray partnered with the support of the NNSA ASC program to develop Red Storm, the most successful massively parallel supercomputer to date. The goal of the design was to create a balanced supercomputer that achieves high performance on real applications. Not only did Sandia researchers play a key role in the design of Red Storm, they developed the operating system that runs the machine. The commercial version of Red Storm, XT3/4, has achieved considerable success as evidenced by its worldwide sales. Cray XT3/4 sites include the Swiss National Computing Center, DoD's Stennis Computing Center, DOE's Oak Ridge National Laboratory, National Science Foundation's Pittsburgh Supercomputing Center, DOE's National Energy Research Scientific Computing Center, and UK's Atomic Weapons Establishment.

As initially configured, Red Storm provides over 10,000 compute nodes for massively parallel computations. Application teams from the three defense laboratories are successfully using Red Storm to provide computational results in support of the NNSA Stockpile Stewardship Program.

CSRI: A Model for U.S. Competitiveness in HPC

Sandia recently opened the Computer Science Research Institute (CSRI) which brings together researchers from universities and the national laboratories in an exciting and dynamic environment to address research problems in parallel computing, computer science, computational science, and mathematics to develop new capabilities in modeling and simulation.

CSRI has become a model for government, industry, and university collaboration. HPC results from Sandia, for example, played an integral role in helping NASA understand the underlying cause of the shuttle *Columbia* accident.



Researchers at Sandia's Visualization Laboratory discuss a computer simulation and analysis showing the impact of a foam piece along the leading edge of the space shuttle *Columbia's* wing.

Sandia's Computer Science Research Institute is a focal point for collaborations. The CSRI hosts over 200 visitors per year, including over 40 summer students and faculty. Other collaborations include research projects, post-docs, sabbaticals and four to six workshops per year. See http://www.cs.sandia.gov/CSRI for more information.