NNSA NEWS

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# NNSA Laboratories Each Complete First 3D Simulations of a Complete Nuclear Weapon Explosion

Scientists at the National Nuclear Security Administration's (NNSA) Los Alamos and Lawrence Livermore national laboratories have completed two of the largest computer simulations ever attempted, the first full-system three-dimensional simulations of a nuclear weapon explosion.

These simulations signify completion of an important milestone in the maturing of NNSA's Stockpile Stewardship Program, which is responsible for maintaining the safety, security and reliability of the nation's nuclear deterrent. Both calculations ran on the ASCI White machine — the world's fastest and most capable supercomputer — at Lawrence Livermore National laboratory in Livermore, California.

"With this accomplishment, NNSA has advanced the state of the art in computer simulation," said Secretary of Energy Spencer Abraham. "All those involved -- from NNSA, the laboratories and the private sector -- are to be congratulated for their efforts."

Achievement of this "full-system" milestone is crucial to the mission of the NNSA and its national security laboratories.

"This is a significant technical achievement," said NNSA Administrator John Gordon. "The NNSA's role in spurring the development of some of the fastest computers in the world is already paying dividends. We can now simulate an entire nuclear weapon explosion and learn critical information about the nation's weapons stockpile as it ages."

Two years ago, Los Alamos and Livermore scientists completed the first 3D simulations of, respectively, a weapon secondary and a weapon primary, the two stages of modern nuclear weapons. The new simulations build on the experience gained in those achievements to enable simulations of a weapon's complete operation.

Being able to simulate a complete weapon system allows national laboratory researchers to examine key physics issues through a combination of simulation, precision experiments, and analysis of data from past nuclear tests. Understanding these physics issues is crucial to the manufacture of replacement weapon components and the refurbishment of aging stockpile weapons.

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The two code teams used different successful approaches to meeting the milestone requirement and both completed their simulations more than two months ahead of schedule. A laboratory-sponsored external review panel of distinguished physicists and computer scientists conducted a detailed independent review of the computational methods and results of these simulations and affirmed the success of both approaches.

Los Alamos' Crestone Project team worked with Science Applications International Corp. (SAIC) and Lawrence Livermore computer scientists on supercomputers at the two laboratories. Although researchers prepared, ran, and revised codes for their simulation for about seven months, the actual run time was about four months of round-the-clock computing. The simulation used more than 480 million cells on 1,920 of the 8,192 processors on the IBM ASCI White machine at Livermore. The actual time on the central processing unit was 2,931 wall-clock hours or 122.5 days -- more than 6.6 million CPU hours -- equivalent to computing continuously on a high-end home computer for more than 750 years.

"Our simulation was run remotely from Los Alamos on the White machine at Livermore, more than 1,000 miles away." Los Alamos' Crestone Project Leader Bob Weaver explained. "Thanks to the secure network connecting the laboratories, this remote computing effort worked almost as easily as computing on a local supercomputer at Los Alamos."

Because the simulation ran remotely, researchers at Los Alamos viewed the data using LANL's 3.1 teraOPS Silicon Graphics Blue Mountain supercomputer and its EnSight graphics package developed by Computational Engineering International. The data transmitted between the laboratories was about 35 times the information contained in the Library of Congress.

The expert panel reviewing the Los Alamos simulation said "the Crestone effort also far exceeded the milestone requirements…This is a unique capability within ASCI and adds strength to the overall program."

The Livermore simulation ran on more than 1024 processors of the ASCI White machine and took 39 days to execute. The review panel chair, MIT Professor Dr. Kim Molvig, said that the LLNL calculation "went above and beyond the milepost definition to far exceed the milepost requirements." The simulation produced important information about the nuclear weapons stockpile, including the primary and secondary yields, for comparison to past nuclear test data.

This latest achievement is part of the NNSA's Advanced Simulation and Computing (ASCI) effort, which involves NNSA employees, teams from Lawrence Livermore, Los Alamos, and Sandia National laboratories, and key partners from the U.S. computer industry.

The first phase of the program focused on development of computers of unprecedented speed and capacity. Now it also sponsors development of new multiple-physics simulation codes needed to identify, diagnose, and correct potential concerns about the aging U.S. nuclear stockpile.

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