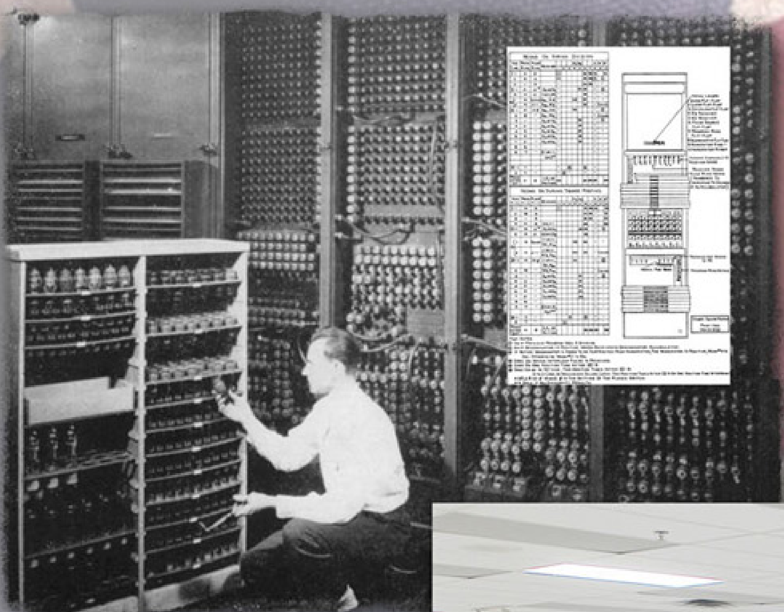
ADVANCED SIMULATION AND COMPUTING



program plan

august 2003

SAND2003-130P

ON THE COVER:

THEN:

ENIAC (Electronic Numerical Integrator And Computer)—the world's first electronic digital computer—was developed by Army Ordnance to compute World War II ballistic firing tables. Dedicated in 1946, ENIAC was the prototype from which most other modern computers evolved. ENIAC's first application was to solve an important problem for the Manhattan Project. Involved were Nicholas Metropolis and Stanley Frankel from Los Alamos National Laboratory.—*William T. Moye U.S. Army Research Laboratory (ARL) Historian, January 1996*

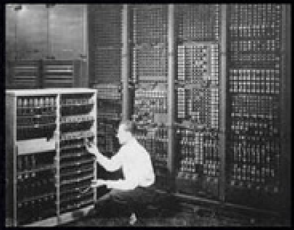
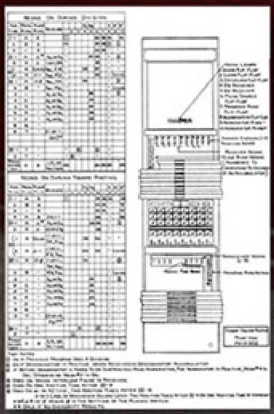


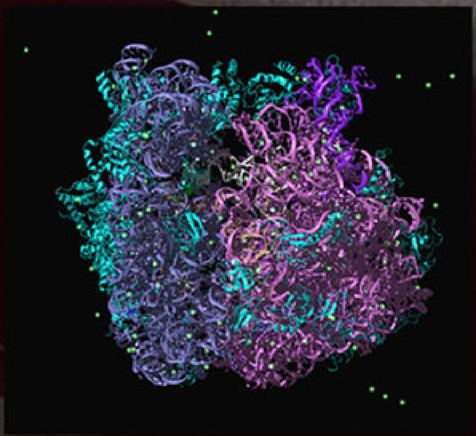
Photo caption: Replacing a bad tube meant checking among ENIAC's 19,000 possibilities. U. S. Army Photo



A chart from an ENIAC manual shows the status of neon lamps during different mathematical functions. The operation of the machine was monitored by noting the status of these lamps on the front of the machine.

NOW:

The Los Alamos ASCI supercomputer, Q, a 30-teraOPS computer, is now being installed in its new facility, the Nicholas C. Metropolis Center for Modeling and Simulation. ASCI Q, the next generation of large-scale computing capability for the Complex, will be a multilaboratory resource once delivered, installed, and stabilized.

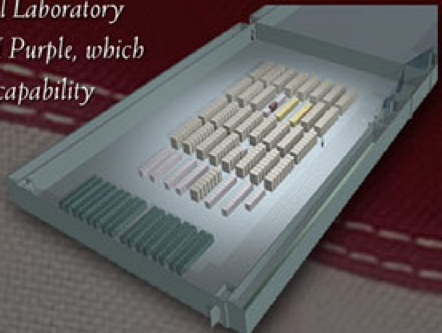


This 2 million-atom molecular dynamics simulation of the 70S ribosome in explicit solvent, performed on the Q supercomputer, is approximately 6.2 times larger than the largest performed to date in biology and has set a new state-of-the-art in biomolecular simulation. The long-term goal of this work is to understand antibiotics, used as a first defense against Antrhrax and other biological agents.

THE FUTURE:

Sandia National Laboratories' Red Storm computer is to be operational in2004. It will be a 20/40 teraOPS computing system.

Lawrence Livermore National Laboratory is currently developing ASCI Purple, which will deliver a 100-teraOPS capability to the three labs in 2005.



ADVANCED SIMULATION AND COMPUTING PROGRAM PLAN

AUGUST 2003

Advanced Simulation and Computing
PROGRAM PLAN
AUGUST 2003

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II. Executive Summary

The Stockpile Stewardship Program (SSP) is a single, highly integrated technical program for maintaining the safety and reliability of the U.S. nuclear stockpile in an era without nuclear testing and without new weapons development and production. The SSP will use past nuclear test data along with future non-nuclear test data, computational modeling and simulations, and experimental facilities to advance understanding of nuclear weapons. It will include stockpile surveillance, experimental research, development and engineering programs, and an appropriately-scaled production capability to support stockpile requirements. This integrated national program will require continued use of current facilities and programs along with new experimental facilities and computational enhancements to support these programs.

The Advanced Simulation and Computing program (ASCI)[1] is the cornerstone of the SSP computational enhancement, developing and using simulations to study advanced nuclear weapon design and manufacturing processes, accident scenarios, weapons aging, and the resolution of Significant Finding Investigations (SFIs). This requires a balanced system of hardware, simulation software, and computer science solutions.

To maintain long-term stewardship of the stockpile, two multi-faceted objectives must continue to be met by ASCI:

- Deliver validated physics and engineering models using more accurate data, enabling simulations of the performance of nuclear weapons in a variety of environments. Execute model and code development to provide capabilities needed to support refurbishments, resolve significant findings, and meet evolving future requirements.
- Provide a computing environment, sized and supported for the simulation requirements of the science-based SSP. Implement a balanced computing platform acquisition strategy to deploy computing resources to meet SSP needs for capacity and high-end capability simulations.

The ASCI Program Plan (PP) details the strategy and deliverables to accomplish the FY 2004-2009 multi-faceted objectives, including program goals, strategies, and performance measures. Additionally, ASCI Level 1 milestones and the top ten risk items are included. To ensure synchronization with SSP needs, this plan will be reviewed and updated annually.

[1] For historical reasons, the use of the acronym "ASCI" has continued

III. Introduction

ASCI was established in 1996 as an essential element of the Stockpile Stewardship Program (SSP) to provide nuclear weapons simulation and modeling capabilities. Prior to the start of the nuclear testing moratorium in October 1992, the nuclear weapons stockpile was maintained through (1) underground nuclear testing and surveillance activities and (2) "modernization" (i.e., development of new weapons systems). A consequence of the nuclear test ban is that the safety, performance, and reliability of U.S nuclear weapons must be ensured by other means for systems far beyond the lifetime originally envisioned when the weapons were designed. The National Nuclear Security Administration (NNSA) was established in 2000 to carry out the national security responsibilities of the Department of Energy, including maintenance of a safe, secure and reliable stockpile of nuclear weapons and associated materials capabilities and technologies.

More recently, President Bush stated, "it is vitally important that we continue to ensure the safety, security, and reliability of our Nation's nuclear weapons stockpile." Secretary Abraham recognizes such implications, saying "One of the most sobering and important responsibilities vested in the Secretary of Energy is the duty to certify to the President each year that the U.S. nuclear arsenal is safe, secure, and reliable." The SSP must deal with constraints on non-nuclear testing and issues surrounding the nuclear testing moratorium. Noting the importance of ASCI's role in the SSP, NNSA Administrator Linton Brooks states, "The tools and technologies of Stockpile Stewardship have allowed us to replace and reassess components; develop modifications to weapons systems; and, address many issues in the stockpile, without requiring resumption of nuclear testing."

Since its inception, ASCI has produced capabilities to solve progressively more difficult problems, with its focus on high resolution three-dimensional (3-D) full-system simulation using advanced models and algorithms on high-end parallel computers. A summary of ASCI contributions to SSP follows.

ASCI Contributions to the SSP

- In FY 1996, *ASCI Red* was delivered. *Red*, the world's first teraOPS supercomputer, has since been upgraded to over three teraOPS.
- In FY 1998, *ASCI Blue Pacific* and *ASCI Blue Mountain* were delivered. These platforms were the first 3-teraOPS systems in the world.
- In FY 2000, ASCI successfully demonstrated the first-ever, 3-D simulation of a nuclear weapon primary explosion and the visualization capability to analyze the results; ASCI successfully demonstrated the first-ever, 3-D hostile-environment simulation; and ASCI accepted delivery of *ASCI White*, a 12.3-teraOPS supercomputer.
- In FY 2001, ASCI successfully demonstrated simulation of a 3-D nuclear weapon secondary explosion; ASCI delivered a fully functional Problem Solving Environment for *ASCI White*; ASCI demonstrated high bandwidth distance computing between the three national laboratories; and ASCI demonstrated the initial validation methodology for early primary behavior. Lastly, ASCI completed the 3-D analysis for a stockpile-to-target sequence (STS) for normal environments.

- In FY 2002, ASCI demonstrated 3-D system simulation of a full primary and secondary thermonuclear weapon explosion; and ASCI completed the 3-D analysis for a stockpile-to-target sequence (STS) abnormal environment crash and burn accident involving a nuclear weapon.
- In FY 2003, ASCI delivered a nuclear safety simulation of a complex, abnormal, explosive initiation scenario; ASCI demonstrated the capability of computing electrical responses of a weapon system in a hostile (nuclear) environment; and ASCI delivered an operational 20-teraOPS platform on *ASCI* Q machine.
- Starting in FY 2004, ASCI will provide integrated codes with focused validation to support the annual certification of the stockpile, and to assess manufacturing options and impact in support of DynEx experiments. These efforts will continue beyond FY 2009. ASCI will provide the simulation capabilities for experiments and diagnostic design to support completion of the first stewardship experiment on the National Ignition Facility (NIF). In addition, ASCI will support the life extension refurbishment of the W87.
- By FY 2005, ASCI will identify and document requirements to move beyond a 100-teraOps computing platform to a petaOPS-class systems; ASCI will deliver metallurgical structure and an aging model to support pit lifetime estimations, based on plutonium-spiked alloy. ASCI will provide the necessary simulation codes to support the development of advanced warhead concepts, and the capability to conduct underground nuclear testing as part of the NNSA national priorities.
- By FY 2006, ASCI will develop, implement, and validate an initial physics and engineering capability in advanced ASCI simulations and benchmark for the W76 and W80 against legacy codes and experiments; ASCI will support the completion of B61 and W80-3 warhead certifications, using quantified design margins and uncertainties; and ASCI will provide a basic 100-teraOps platform user environment supporting the tri-laboratory Directed Stockpile Work (DSW) and Campaign simulation requirements. ASCI will provide data for model development and Verification and Validation (V&V) to support hydro test activities, as defined in the National Hydro test Plan; ASCI will provide the integrated codes to assess manufacturing options and impacts to support the CD-1 approval on the Modern Pit Facility. In addition, ASCI will support the life extension refurbishment of the first production unit for the W80-3.
- By FY 2007, ASCI will support the completion of the W76-1 warhead certification, using quantified design margins and uncertainties; ASCI will also provide a robust 100-teraOPS platform production environment supporting DSW and Campaign simulation requirements. In addition, the 200-teraOps platform will be sited at LANL.
- By FY 2008, ASCI will deliver the codes for experiment and diagnostic design to support the CD-4 approval on the NIF.
- By FY 2009, a modern baseline of all enduring stockpile systems, using ASCI codes, will be completed.

By FY 2013, ASCI will continue to deliver codes for experiment and diagnostic design to support the indirect-drive ignition experiments on the NIF.

IV. Mission

PROVIDE LEADING EDGE, HIGH-END SIMULATION CAPABILITIES NEEDED TO MEET WEAPONS ASSESSMENT AND CERTIFICATION REQUIREMENTS

To meet its mission in FY 2004-2009, ASCI will:

- Continue the development of high-performance, full-system, predictive codes to support weapon assessments, manufacturing process analyses, accident analyses, and certification.
- Stimulate the U.S. computer manufacturing industry to create the powerful high-end computing capability required by ASCI applications.
- Create a computational infrastructure and operating environment that makes ASCI computing capabilities accessible and usable.

V. Vision

PREDICT, WITH CONFIDENCE, THE BEHAVIOR OF NUCLEAR WEAPONS, THROUGH COMPREHENSIVE, SCIENCE-BASED SIMULATIONS

ASCI will focus on improving the physics models that will be incorporated into the simulation codes to deliver higher-performance, higher-fidelity physics, predictive codes. Additionally, the Verification and Validation (V&V) program will provide high confidence in computational accuracy, by systematically measuring, documenting, and demonstrating the predictive capability of codes and their underlying models.

VI. Strategic Goal

PREDICTIVE SIMULATION AND MODELING TOOLS, SUPPORTED BY NECESSARY COMPUTING RESOURCES, TO SUSTAIN LONG-TERM STEWARDSHIP OF THE STOCKPILE

Development and implementation of comprehensive methods, and tools for certification, to include simulations, is one of the top Defense Programs (DP) priorities that will meet the SSP vision:

> To be an integrated nuclear security enterprise, consisting of research and development (R&D), tests and production facilities that operates a responsive, efficient, secure, and safe, nuclear weapons complex and that is recognized as preeminent in personnel, technical leadership, planning, and program management.

To achieve the SSP vision, ASCI's focus will be to provide predictive simulation and modeling tools, supported by necessary computing resources, to maintain long-term stewardship of the stockpile. The ASCI objectives are:

Objective 1

Deliver validated physics and engineering models using more accurate data, enabling simulations of the performance of nuclear weapons in a variety of environments. Execute model and code development to provide capabilities needed to support refurbishments, resolve significant findings, and meet evolving future requirements.

Objective 2

Provide a computing environment sized and supported for the simulation requirements of the science-based SSP. Implement a balanced computing platform acquisition strategy to deploy computing resources to meet SSP needs for capacity and high-end capability simulations.

VII. Strategy

A three-tiered strategic approach, implemented within a tri-lab framework, has been established to accomplish ASCI's strategic goal:

1. Near-Term (FY 2004-2005): Contingent on availability of computational resources, ASCI plans to provide validated computer codes that apply to the STS in abnormal environments, focused secondary capabilities, and enhanced primary and nuclear safety simulation capabilities. ASCI also anticipates the final delivery and checkout of the 40-teraOPS Red Storm platform at Sandia National Laboratories (SNL). ASCI will identify requirements to move beyond a 100teraOPS to petaOPS platforms. The delivery and initial checkout of the 100-teraOPS Purple platform at Lawrence Livermore National Laboratory (LLNL) will mark accomplishment of one of the major original ASCI computing platform goals.

2. Mid-Term (FY 2006-2010): By FY 2010, ASCI envisions three outcomes:
   - The delivery of well-validated physics and engineering models and more accurate data, enabling simulations of nuclear weapons performance in a variety of environments, with greater reliance on predictive science. This will include providing simulation capabilities to benchmark for the W76 and W80 simulations against legacy codes and experiments;
   - The availability of a computing environment, sized and supported, to achieve the necessary level of simulation to accomplish the SSP mission. This will include providing multiple 100teraOPS class platform production environments; and
   - The capability of the ASCI codes to complete modern baseline of all enduring stockpile systems.

3. Long-Term (FY 2011-2020): In the long term, ASCI plans to provide the predictive simulation capabilities necessary to continue supporting weapons systems certification and refurbishment schedules. This includes SFI resolution, physics and engineering components and system analysis, large-scale experiment design and analysis, and ability to meet new design requirements. ASCI will continue to provide the balanced computing and data assessment environments to meet mission requirements.

Technical Strategy

A technical strategy and integration with the three-tiered strategic approach is necessary to meet the needs of the SSP. The technical strategy reflects the direction ASCI will follow in FY 2004-2009.

- *Simulation and Science Strategy* – this will transform a traditional two-dimensional (2-D) simulation paradigm into one that has a robust suite of advanced 2-D codes and fully capable 3-D codes. This paradigm shift necessitates the incorporation of improved physics models and algorithms into 2-D and 3-D codes that are formally verified and validated.
- *Platform Strategy* – this will leverage the U.S. computer industry to achieve cost-effective performance, while encouraging the development of scalable architectures that meet SSP capability requirements.
- *Computational Environment Strategy* – this will provide the tools and utilities necessary to ensure effective utilization of platform resources, as well as promoting research and development initiatives to enhance the future computational environment.

To ensure successful execution of the ASCI strategy, an organizational structure, program management process, and performance measurement mechanisms have been instituted within the ASCI tri-lab framework.

ORGANIZATION

ASCI's organizational structure is designed to foster a focused, collaborative effort to achieve program objectives. The following elements make up this structure:

- *Executive Committee.* This body consists of a high-level representative from each NNSA laboratory, and a senior member in the Advanced Simulation and Computing Office at NNSA Headquarters (HQ). The Executive Committee sets overall policy for ASCI, develops programmatic budgets, and oversees the program execution.

- *Program Element Management Teams.* These teams are responsible for planning and execution of the implementation plans for each of the ASCI program elements: Advanced Applications, V&V, Materials and Physics Modeling (M&PM), Problem Solving Environment (PSE), DisCom, PathForward, Visual Interactive Environment for Weapons Simulation (VIEWS), Physical Infrastructure and Platforms (PI&P), Computational Systems and Simulation Support, Advanced Architectures, Alliances, Institutes, and One Program/Three Labs (OPTL). The program element management teams have a primary and alternate representative from each laboratory, and the corresponding program element manager from NNSA-HQ. These teams work through the executive committee. Tasking from NNSA-HQ for these teams originates from the ASCI Federal Program Manager and is communicated through the executive committee.
- *ASCI's NNSA-HQ Team.* This team consists of NNSA Federal employees and contractors, in concert with laboratory and plant representatives. The ASCI HQ team is responsible for ensuring that ASCI supports the SSP. The team facilitates ASCI interactions with other government agencies, the computer industry, and universities. In addition, the team sets programmatic requirements for the laboratories, and reviews management and operating contractor performance.

PROGRAM MANAGEMENT PLANNING AND EXECUTION PROCESS

ASCI program management uses a planning process made up of the following elements:

- *ASCI Program Plan (PP)* – provides the overall direction and policy for ASCI. This functions as a strategic plan, and it identifies key issues and work areas for ASCI in the next six years. This document is reviewed annually to ensure ASCI supports SSP needs.
- *ASCI Implementation Plan (IP)* – this document is prepared annually and describes the work planned in two-year intervals at each laboratory to support the overall ASCI objectives.
- *Program Milestones* – ASCI milestones are a subset of NNSA National Level 1, and Level 2, and other lower level laboratory specific milestones. Level 1 milestones are milestones that are national priorities or are high visibility at NA-10 or higher levels, usually require multi-site and/or multi-program coordination, and provide integration across ASCI, DSW, and the Campaigns. Level 1 milestones may be specific to ASCI or meet other SSP objectives with significant ASCI support. Level 2 milestones demonstrate the completion of advanced ASCI capabilities, and often support ASCI Level 1 milestones, DSW deliverables, and/or major Campaign milestones. Level 3 (and below) milestones demonstrate the completion of important capabilities within a program element and measure technical progress at the subprogram level; these milestones are lab-specific and managed by the laboratories. Progress on Level 1 and Level 2 milestones is reported quarterly to the NNSA through NA10QPRs/NA-1 annual technical review.
- *Program Collaboration Meetings* – The following meetings facilitate collaboration among the three national laboratories, industry, and universities:
  - *Principal Investigator Meetings.* These annual meetings provide a forum for ASCI principal investigators to meet and discuss progress in their respective research areas. These meetings allow principal investigators at each laboratory to present and discuss their work with their peers at the other laboratories. In addition, the meetings include participants from outside of the weapon laboratories, in order to provide broader ASCI peer review. The meetings also serve as an annual technical review for the DOE-HQ team.

- *Executive Committee Meetings.* The ASCI Executive Committee meets twice a month, via teleconference. These meetings ensure that relevant issues are identified, discussed, and resolved in a timely manner. The teleconferences are supplemented with quarterly face-to-face meetings.
- *Program Element Meetings.* ASCI program element teams conduct individual meetings to discuss progress, issues, and actions. The frequencies of these meetings depend on the discretion of the ASCI HQ program manager and his/her counterparts at the laboratories. These meetings identify issues that need to be elevated to the Executive Committee.

- *External Reviews* – External reviews are conducted regularly by the laboratories to provide independent, critical insight to the laboratories on the technical progress of the ASCI program. The review panels consist of experts from academia, industry, and the national laboratories. Results of the reviews are provided to the laboratories and ASCI HQ observers. These reviews augment other high level reviews by laboratory, University of California, and Lockheed-Martin review committees.
- *Performance Measurement* – These include performance indicators and annual performance targets, established to annually measure the successful execution of the program (See Appendix B.) Laboratory managers are responsible for measuring and managing the performance of the projects within their purview. Each laboratory reports quarterly performance to NNSA in the form of accomplishments and progress toward milestones.

VIII. ASCI Level 1 Milestones

Level 1 milestones specific to ASCI, as listed in Table 1 below, are designed to track ASCI's progress toward accomplishing its strategic goal, meeting its performance measures, and providing the predictive capabilities and computing power necessary to meet SSP needs. This table also identifies interfaces with other DP components in order to accomplish ASCI level 1 milestones. Appendix A lists all Defense Program, NA-10, level 1 milestones, including ASCI, which must be accomplished to meet the SSP mission.

Table 1: ASCI Level 1 Milestones and Interfaces with DP Components for FY 2004-2009

Milestone	Responsibility	Date	Input Entity	Capability to be delivered from Input entity
Document the requirements to move beyond a 100teraOPS ASCI computing platform to a petaOPS platform	LANL, LLNL, SNL	FY05 Q1	DSW, Science Campaigns	Stockpile and science drivers for simulation
Develop, implement, and validate an initial physics/engineering capability in advanced ASCI simulations and benchmark for the W76 and W80 against legacy codes and experiments	LANL, LLNL, SNL	FY06 Q3	DSW, C1, C2, C4	Stockpile requirements, certification methodology, data for validation
Provide a 100teraOPS Platform environment supporting tri-lab DSW and Campaign simulation requirements	LLNL	FY07 Q1	DSW, Science Campaigns	Simulation requirements
Complete modern baseline of all enduring stockpile systems with ASCI codes	LANL, LLNL, SNL	FY09 Q4	DSW	System descriptions for simulation input; stockpile issues to be addressed; test data for validation

IX. ASCI Components

The ASCI program comprises five components (program areas): Defense Applications and Modeling (DAM), Simulation and Computer Science (S&CS), Integrated Computing Systems (ICS), University Partnerships, and ASCI Integration. This section describes these components, their respective strategies, and performance indicators.

Defense Applications and Modeling (DAM)

This program area develops and maintains all weapons codes used to support stockpile stewardship needs, including weapon design and assessments, accident analyses, certification issues, and manufacturing process studies. The development of high-fidelity, full-system codes requires new physics and materials models, improved algorithms, general code development, and a concerted effort in the verification of codes and their validation against experimental data. The DAM program area is composed of three program elements: Advanced Applications, V&V, and Materials and Physics Modeling.

The DAM strategy for ASCI is to transform from a traditional 2-D simulation paradigm into one that has a robust suite of advanced 2-D and fully capable 3-D codes. This paradigm shift necessitates the incorporation of improved physics models and algorithms into codes that are formally verified and validated. The adequacy of this strategy will be assessed according to the following performance indicators:

- Peer-reviewed progress, according to schedule, toward a validated full-system, high-fidelity simulation capability.
- Application of ASCI codes to the analysis of weapon system components and primary/secondary/engineering systems, as part of the annual assessment of all stockpile systems and execution of the Life Extension Programs (LEPs) and other stockpile activities.

ADVANCED APPLICATIONS

Advanced Applications develops enhanced 2-D codes and highly capable 3-D computer codes to provide an unprecedented level of physics and geometric fidelity for full-system, component, and scenario-related weapons simulations. These codes directly support the SSP and require the integration of all ASCI elements, particularly the materials and physics models currently being developed and the multi-teraOPS platforms in operation and planned for the future.

Elements of strategy for Advanced Applications include:

- Focus on highest priority applications needed to support DSW.
- Focus on coupling of multiple, high-fidelity physics models (coupled multi-physics) for end-to-end simulations, with a minimum of empirical correlations or designer steering.
- Integrate high-fidelity physics and numerical methods for treating complex geometries in 2-D and 3-D computer codes.
- Focus on full-system, component and scenario simulations.
- Design and implement numerical algorithms to meet ASCI application requirements.

- Accelerate code performance by developing, analyzing, modifying, and new computational techniques to efficiently exploit new computer architectures.

Verification and Validation (V&V)

V&V assesses models and simulation codes against analytic solutions and experimental data to establish confidence in the simulations used for nuclear weapon certification and to resolve high consequence, nuclear stockpile problems. V&V activities include quantifiable assessment of the accuracy of thermal response models in STS abnormal environments; quantitative assessments of physics models and simulation capabilities related to secondaries; and quantifiable assessment of enhanced primary capabilities and the ability to simulate nuclear safety in complex abnormal environments.

Elements of the strategy for V&V include:

- Provide quantified confidence bounds for weapons simulations that support the SSP, by systematically measuring, documenting, and demonstrating the predictive capability of codes and their underlying models, compared to known analytical solutions and experimental data.
- Provide requirements for, and compare calculations against, experimental validation data obtained through the SSP.
- Provide the basis by which computational uncertainties are evaluated and assessed.
- Improve software engineering tools and practices for application to ASCI simulations.

Materials and Physics Modeling (M&PM)

This program element develops models for physics, material properties, and transport processes that are essential to the simulation of weapons, under all life-cycle conditions. As platforms allow simulations of higher resolution, models are becoming more detailed, providing improved confidence in the simulations.

Elements of the strategy for M&PM include:

- Develop equation-of-state (EOS) and constitutive models for weapons-relevant metals, including phase diagrams and dynamic response.
- Develop physics-based models predicting the properties of plutonium as it ages, due to self-irradiation.
- Develop physics-based models of high-explosives, including thermal, mechanical, and constitutive properties of unreacted explosives and explosive products, decomposition kinetics, detonation performance, and response in abnormal environments.
- Develop physics-based models for corrosion, polymer degradation, and thermal-mechanical fatigue of weapon electronics.
- Develop physics-based models of melting and decomposition of foams and polymers in safety-critical components.
- Develop physics-based models of microelectronic and photonic materials under aging and hostile environments.

Simulation and Computer Science (S&CS)

S&CS develops and deploys the infrastructure necessary to make the ASCI platforms available to weapons scientists and analysts. This infrastructure includes wide-area networks that allow remote users to securely run applications, software tools for application development and execution tailored to ASCI supercomputer architectures, and advanced scientific visualization and data analysis for interpretation and understanding of calculation results. The S&CS program area is composed of the Problem Solving Environment (PSE), Distance Computing (DisCom), PathForward, and the Visual Interactive Environment for Weapons Simulation (VIEWS).

The S&CS strategy is to successfully balance DP laboratory, academia and industry computer science research and development, thus delivering the infrastructure necessary to utilize the new codes and systems provided and maintained by DAM and ICS. Based on S&CS technology roadmaps that emphasize ASCI scalability needs, S&CS software tools and environments are developed to unite DAM and ICS. The adequacy of this strategy will be assessed according to the following performance indicator:

- Peer-reviewed progress, according to schedule, toward a validated full-system, high-fidelity simulation capability.

Problem Solving Environment (PSE)

The PSE program element develops a computational infrastructure that allows the efficient execution of applications on ASCI computing platforms and access to the platforms from the desktops of scientists. This computational infrastructure includes local-area networks, advanced storage facilities, and software development tools. PSE will deliver a common and usable application development environment for ASCI computing platforms, such as the Q, Red Storm and Purple systems; an end-to-end, high-performance input/output (I/O) and storage infrastructure; and appropriate access to ASCI supercomputers and other ASCI resources across the three weapons laboratories.

Elements of the strategy for PSE include:

- Create a common, usable, and robust application development and execution environment for ASCI computing platforms and ASCI-scale applications, enabling code developers to readily meet the computational needs of weapon scientists and engineers.
- Produce an end-to-end, high-performance I/O, networking and storage archive infrastructure encompassing ASCI platforms and operating systems, large-scale simulations, and data-exploration capabilities to enable efficient ASCI-scale computational analysis.
- Ensure secure, effective access to "initial delivery" and "general availability" ASCI supercomputers, as well as to other ASCI resources, across the three NNSA national laboratories such that ASCI's supercomputers are fully usable for local code development and execution, while being well integrated into the tri-lab distributed computing environment.

Distance Computing (DisCom)

DisCom's programmatic goal is to provide secure, high-speed, remote access to ASCI supercomputers for ASCI users. Secure computing at a distance is necessary for the three laboratories to access all ASCI supercomputing platforms, as required. This distance capability involves the creation of a high-speed, parallel, secure infrastructure architecture (both hardware and software), development and implementation of monitoring and testing capabilities, development of service applications and user support, and partnering with the PSE and VIEWS elements, to integrate services and security functions necessary for efficient remote access. In addition, DisCom aims to enable high performance ASCI computing at the Y-12 and Kansas City Plants.

Elements of the strategy for DisCom include:

- Develop and maintain a wide-area infrastructure (links and services) that enables distant users to operate on remote computing resources.
- Provide a reliable, available, secure (RAS) environment for distance computing, through system monitoring and analysis, modeling and simulation, and technology infusion.
- Develop and implement user support services that complement the Computational Systems and Simulation Support program element activities in support of distance users, through user acceptance testing, user guides, web-accessible information about the computing environments, and web-accessible system status.
- Enable remote access to ASCI applications, data, and computing resources, to support computational needs at the plants.

PathForward

The goal of this program element is to stimulate development and engineering activities in technology areas such as interconnects, runtime system, visualization, storage, and advanced commercial-off-the-shelf (COTS) technologies needed for future ASCI-class computer systems.

Elements of the strategy for PathForward include:

- Stimulate development of commercially viable building blocks for construction of future ASCI supercomputer systems.
- Focus on opportunities that expand the capabilities, performance, availability, expertise, and products that comprise regular business plans in the private computer industry.

Visual Interactive Environment for Weapon Simulation (VIEWS)

The VIEWS programmatic goal is to deliver leading-edge visualization and data management software and hardware to provide the "see and understand" capabilities needed to view, interact, and analyze data produced by ASCI simulations. VIEWS provides delivery of high-end graphics to workspaces, enabled by emerging technologies that include improved liquid crystal display (LCD) monitors, high-end personal computer (PC) graphics technologies, gigabit ethernet data and video delivery to offices, PC-cluster based scalable rendering, and software to exploit such technologies. VIEWS support of both multi- and single-user visualization capabilities will play a pivotal role in application development, debugging, and assessment of near-term performance targets.

Elements of the strategy for VIEWS include:

- Develop high-performance Data and Visualization Corridors (DVCs) that allow exploration, manipulation, extraction, delivery and management of massive, complex data by local and remote users in their offices and in collaborative workspaces.
- Partner with academia, industry, and federal agency research and development, as needed, to focus and leverage technology development.

Integrated Computing Systems (ICS)

Meeting ASCI's program requirements for developing advanced applications requires large, complex application codes that drive the scale of computing machinery, and the infrastructure that supports these large systems and simulations. The goal of ICS is to develop and provide these computing resources and infrastructure, and to ensure that applications run satisfactorily on the most appropriate machines, at any given time. The ICS architecture evolves over time or is replaced as necessary. The strategy for integration is to maximize the use of standard tools, common system structures, and code portability, to enable inter-laboratory collaborations. The ICS program area comprises Physical Infrastructure and Platforms (PI&P), Computational Systems, Simulation Support, and Advanced Architectures.

In order to accommodate the paradigm shift taking place through the DAM strategy, ICS acquires powerful ASCI platforms in partnership with U.S. industry and operates computing centers necessary to run the codes. The adequacy of this strategy will be assessed, using the following performance indicators:

- Total capacity of ASCI production platforms, with regards to procurements and system retirements.
- Amount of capability platform acquired.

Physical Infrastructure and Platforms (PI&P)

The PI&P program element acquires computational platforms to support the SSP. The Red Storm system at SNL will be completed in FY 2004. The 100-teraOPS ASCI Purple platform is scheduled for full delivery and installation at LLNL in FY 2005, with an early technology demonstration system in FY 2004. The 200-teraOPS ASCI platform is scheduled for full delivery and installation at LANL in FY 2007.

Elements of the strategy for PI&P include:

- Leverage the enormous commercial investments in technology to build a balanced mix of low-cost capability and capacity systems.
- Develop partnerships with multiple computer companies, to ensure appropriate technology and system development.

COMPUTATIONAL SYSTEMS

This new program element was previously part of Ongoing Computing. The old Ongoing Computing program element has been split into two new elements: Computational Systems and Simulation Support, to provide better programmatic visibility and understanding of driving factors and trends for ASCI computing center costs. Computational Systems supports computational capacity, archival data storage systems and the networking infrastructure at the three laboratories, including systems administration and support personnel, maintenance contracts, and capital operating equipment for these systems.

Elements of the strategy for Computational Systems include:

- Deploy ASCI platforms, as they are acquired.
- Provide system management of the laboratory ASCI computers.
- Deploy and support the necessary networks and archives for laboratory computers.

SIMULATION SUPPORT

Simulation Support provides support services for computing, data storage, networking, and their users, including facilities and operations of the computer centers (including electrical power costs), user help desk services, training, and software environment development that supports the usability, accessibility, and reliable operation of high-performance, institutional, and desktop computing resources at the three laboratories.

Elements of the strategy for Simulation Support include:

- Operate and maintain laboratory facilities that house ASCI computers.
- Operate laboratory ASCI computers and support integration of new systems.
- Provide analysis and software environment development and support for laboratory ASCI computers.
- Provide user services and help desks for laboratory ASCI computers.

ADVANCED ARCHITECTURES

This program element addresses the long-term platform risk issues of cost, power, performance, and physical size, through the study of alternative architectures that may potentially make future ASCI platforms more capable and cost effective. By working directly with high-end computing resource providers, this element provides an opportunity for these providers to explore innovative and novel solutions that could potentially address ASCI's aggressive computing requirements.

Elements of the strategy for Advanced Architecture include:

- Stimulate R&D efforts, through advanced architectures, that explore alternative computer designs, promising dramatic improvements in performance, scalability, reliability, packaging, or cost.

University Partnerships

This element includes activities aimed at training, recruiting, and collaborating with top researchers in key disciplines, required by stockpile stewardship. These partnerships help establish and validate large-scale, multi-disciplinary, modeling and simulation as a viable scientific approach. Computer Science Institutes at the three laboratories, Graduate Fellowships, and University Alliances are all part of this program element.

Elements of the strategy for University Partnership include:

- Encourage strategic alliances and collaboration between the national laboratories and universities.
- Leverage other national initiatives.
- Collaborate with the best R&D programs of other departmental offices, other agencies, universities, and industries
- Attract top researchers in key disciplines for weapon applications.
- Form long-term strategic alliances with a small number of universities and academic consortia, to fund critical efforts dedicated to long-term ASCI issues, such as high confidence in simulations.
- Establish smaller-scale collaborations with individual investigators and research groups, to work on focused problems, such as fluid turbulence.
- Recruit exceptional students to career opportunities at the NNSA national laboratories.

Integration Program

This program element integrates specific efforts that are not covered by the technical program elements. Integration includes OPTL, the annual Supercomputing Conference, collaboration meetings, program planning, topical investigations, and outreach and crosscut projects. The Integration Program facilitates cooperation and collaboration among the weapons laboratories, improves program visibility within the high-performance computing community, and enhances the overall operations of the ASCI program.

Elements of the strategy for Integration Program include:

- Operate ASCI as a single, tri-lab program activity, with seamless management and execution across the laboratories.
- Sponsor annual principal investigator meetings.
- Encourage collaboration on initiatives, and share hardware and software resources.
- External workshops and meetings.

X. Integration

Continual collaboration between ASCI, Campaigns, and DSW is a major strength of the SSP. Joint efforts in software development, code verification and validation, and tool-suite application are good examples of this collaboration.

- *Software Development* – ASCI code project priorities are guided and coordinated with designers, via specific tasks and schedules, to meet DSW requirements and thereby accommodate weapon systems' modifications, as part of Stockpile Life Extension Programs (SLEPs).
- *Code Verification and Validation* – The verification and validation of ASCI codes is conducted by ASCI and DSW, as part of the formal stockpile stewardship V&V process. Experiments designed to address specific weapons issues are used to validate codes. Codes are also verified against idealized scenarios, with known solutions.
- *Tool-Suite Application* – Weapons designers use the ASCI simulation and modeling tool suite to assess unresolved surveillance SFIs, by using 3-D simulations and new numerical techniques in the ASCI simulation codes. These capabilities are vital to SLEP activities, because they provide simulation and modeling tools needed to certify the performance, safety, and reliability of aging or refurbished nuclear weapons. There are many examples of these activities:
    - LANL and LLNL are using the ASCI tools and technologies to address physics and engineering issues associated with the W88, W76, B61, and W80.
    - SNL was able to reduce the number of development tests in a stockpile-engineering product, because of the high confidence in validated ASCI simulations. This reduction in development tests allowed acceleration of the development schedule and an improved allocation of existing resources.
    - ASCI simulations and tools are being used to refine and optimize casting and manufacturing processes. As a result of collaborative efforts with manufacturing experts and a strong V&V process, increased confidence in casting simulations has resulted in improved mold designs and manufacturing processes.

Integration with DSW

Coordination between ASCI and DSW is a significant aspect of the execution of redesign studies, during which modifications are made to a system, and models must be incorporated into the codes that account for changing parameters or system specifications. Simulations are also needed to model previous manufacturing processes for weapon components and to define new, cost-effective, safe, and environmentally compliant manufacturing processes that will allow consistent nuclear weapon safety, security, and reliability in the future.

Integration with DP Science Campaigns

The development of predictive capabilities relies on a strong experimental program to support the assessment of stockpile issues and to provide materials and physics data needed to validate new scientific models and theories incorporated into the simulation codes. DP's Science Campaigns provide the science development, testing, and experiments needed to manage the nuclear weapons stockpile. In the previous era of test-based confidence, this program provided direct answers about the safety, security, and reliability of the stockpile. In the current era, the focus has shifted to a simulation-based confidence, which requires a close connection between ASCI and the Science Campaigns. Using facilities such as NIF at LLNL, the Dual Axis Radiographic Hydrodynamic Testing (DARHT) Facility at LANL, and the Microsystems and Engineering Sciences Applications (MESA) Facility at SNL, the Science Campaigns produce significant quantities of high-quality physics data. Data from these experimental programs provide ASCI with the raw material necessary to evaluate and improve physics models to better characterize weapons' performance and aging.

Integration with the DOE Office of Science

Certain technical problems that arise in terascale computing are generic to scientific simulation and apply equally well to applications within both the NNSA and DOE's Office of Science. This includes I/O and archival management of large scientific data sets, the analysis and visualization of petabyte data sets, the operating systems for high-performance computing, and mathematical algorithms and software for solving complex problems. While there are significant differences in the detailed nature of the scientific problems being addressed, there is still much to be gained by exploiting the natural synergy between the high-performance computing program within the Office of Science and ASCI. Both programs are collaborating to identify areas of common interest and to establish appropriate coordination of efforts.

XI. Risk Management

Risk management is a process for identifying and analyzing risks, encouraging mitigation and contingency planning to minimize potential consequences of identified risks, and monitoring and communicating up-to-date information about risk issues. Risk management is about identifying opportunities and avoiding losses. A "risk" is defined as (1) a future event, action, or condition that might prevent the successful execution of strategies or achievement of technical or business objectives, and (2) the risk exposure level, defined by the likelihood or probability that an event, action, or condition will occur, and the consequences, if that event, action, or condition does occur. Table 2 summarizes ASCI's top ten risks, which are managed and tracked.

XII. Program Funding

ASCI funding is allocated to cover people, hardware, and contract costs incurred by the ASCI divisions. Table 3 shows the FY 2004-2009 distributions for the program. The budget is reported and analyzed monthly by ASCI's laboratory resource analysts and by laboratory management. Funding and costs are tracked and reported at the program element level using DP's Budget and Reporting (B&R) classification codes and Financial Information System. These tracking systems are extended in greater detail down to the level of individual projects.

Table 2: ASCI Top 10 Risks

No	Risk Description	Risk Assessment			Mitigation Approach
		Consequence	Likelihood	Risk Exposure	
1	Compute resources are insufficient to meet capacity and capability needs of designers, analysts, DSW, or other Campaigns.	High	High	**HIGH**	Integrate program planning with DSW and other Campaigns, to ensure requirements for computing are understood and appropriately set; maintain emphasis on platform strategy as a central element of the program; pursue plans for additional and cost-effective capacity platforms.
i2	Designers, analysts, DSW, or other Campaign programs lack confidence in ASCI codes or models for application to certification /qualification.	Very High	Low	**MEDIUM**	Maintain program emphasis on V&V; Integrate program planning with DSW and other Campaign programs to assure requirements needed for certification/qualification are properly set and met.
3	Inability to respond effectively with Modeling & Simulation (M&S) capability and expertise in support of stockpile requirements - near or long term, planned or unplanned (SLEP, SFIs, etc.).	Very High	Low	**MEDIUM**	Integrate program planning, particularly technical investment priority, with DSW and other Campaign programs to ensure capability and expertise is developed in most appropriate areas; retain ability to apply legacy tools, codes, models.
4	Base of personnel with requisite skills, knowledge, and abilities erodes.	High	Low	**MEDIUM**	Maintain emphasis on "best and brightest" personnel base, with Institutes, Research Foundations, and University programs, as central feeder elements of the program.
5	Advanced material model development more difficult, takes longer than expected.	Moderate	High	**MEDIUM**	Increase support to physics research; pursue plans for additional computing capability for physics model development
6	Data not available for input to new physics models or for model validation.	High	Moderate	**MEDIUM**	Work with Science Campaigns to obtain needed data; propose relevant experiments.
7	Infrastructure resources are insufficient to meet designer, analyst, DSW, or other Campaign program needs.	High	Low	**MEDIUM**	Integrate program planning with DSW and other Campaigns, to ensure requirements for computing are understood and appropriately set; maintain emphasis on system view of infrastructure and PSE strategy, as central elements of the program.
8	External regulatory requirements delay program deliverables by diverting resources to extensive compliance-related activities	Moderate	Low	**MEDIUM**	Work with external regulatory bodies to assure that they understand NNSA's mission, ASCI's mission, and the processes to set and align requirements and deliverables, consistent with applicable regulations.
9	Inadequate Problem Solving Environment impedes development and use of advanced applications on ASCI platforms.	Moderate	Very Low	**LOW**	Integrated planning between program elements to anticipate application requirements and prioritize PSE development and implementation.
10	Fundamental flaws discovered in numerical algorithms used in advanced applications require major changes to application development.	Moderate	Very Low	**LOW**	Anticipate or resolve algorithm issues through technical interactions on algorithm research through the Institutes, ASCI Centers, and academia, and focus on test problem comparisons as part of software development process.

Table 3. ASCI Future Funding Profile

ASCI PROGRAM COMPONENTS	FY04	FY05	FY06	FY07	FY08	FY09
Defense Applications and Modeling						
Advanced Applications	144.226	150.793	159.579	166.671	174.080	181.824
Verification and Validation	47.675	49.780	53.812	56.143	58.579	61.126
Materials and Physics Models	69.291	72.062	76.304	79.693	83.234	86.936
Simulation and Computer Science						
Problem Solving Environment	43.982	45.072	47.051	49.119	51.279	53.537
DISCOM	16.514	17.068	17.532	18.018	18.525	19.055
Pathforward	17.800	18.000	15.000	15.000	15.000	15.000
VIEWS	59.791	61.635	63.374	65.191	67.088	69.073
Integrated Computing Systems						
Physical Infrastructure and Platforms	106.977	140.000	164.000	170.000	165.000	165.000
Computational Systems	62.091	64.081	65.239	74.241	71.686	69.111
Simulation Support	58.437	59.413	60.555	69.540	66.962	64.303
Advanced Architectures	0.000	3.000	3.000	3.000	3.000	3.000
University Partnerships						
Alliances	21.437	25.000	25.000	25.000	25.000	25.000
Institutes	24.250	20.980	21.564	22.175	22.812	23.479
Fellowships/Krell	2.000	2.000	2.000	2.000	2.000	2.000
Integration						
One Program / Three Labs	9.411	8.733	7.084	9.499	9.500	9.500
SuperComputing Conference	0.415	0.415	0.415	0.415	0.415	0.415
ADVANCED SIMULATION AND COMPUTING	**684.297**	**738.032**	**781.509**	**825.705**	**834.160**	**848.359**

XIII. Revision

This is a complete revision and rewrite of the ASCI Program Plan, in accordance with the 2003 guidance established by DP's Implementer Team. This Program Plan replaces and supersedes the previous ASCI Program Plan, DOE/DP/ASC-2002-ASCI-Prog-002.

Appendices

Appendix A

Level 1 Milestones

The first part of this appendix includes listing of NA-10 level 1 milestones, in table A-2, for FY2004-2013. ASCI level 1 milestones are highlighted in this table. The second part of this appendix lists all ASCI level 1 milestones prior to FY2004.

Table A-1. NA-10 Level 1 Milestones

#	Affinity Grouping	Milestone	Responsibility	Date Qx FYxx (M/YY)	Sub-program	Associated DP Priority
M1 M2 M3 M4 M5 M6	DSW Production	Meet the delivery requirements (i.e. surveillance, dismantlement, LLC replacement, etc.) established by the P&PD with particular emphasis on meeting established joint DoD and NNSA commitments in accordance with the Directive Schedule.	Plants, SNL LANL, LLNL	Q4 FY04 (9/04) Q4 FY05 (9/05) Q4 FY06 (9/06) Q4 FY07 (9/07) Q4 FY08 (9/08) Q4 FY09 (9/09)	DSW	1, 2, 9
M7 M8 M9 M10 M11 M12	Construction & Infrastructure	Annually, prepare and execute an integrated, comprehensive RTBF/FIRP plan consistent with the Nuclear Weapons Complex Enterprise Strategy to ensure a flexible, responsive, robust infrastructure.	All labs & plants	Q4 FY04 (9/04) Q4 FY05 (9/05) Q4 FY06 (9/06) Q4 FY07 (9/07) Q4 FY08 (9/08) Q4 FY09 (9/09)	RTBF	10, 9
M13 M14 M15 M16 M17 M18	Certification	Annually, assess the safety, security, and reliability of the stockpile and provide the required assessments of certification and reports to the Secretary for submission to the President.	LANL, LLNL, SNL	Q2 FY04 (1/04) Q2 FY05 (1/05) Q2 FY06 (1/06) Q2 FY07 (1/07) Q2 FY08 (1/08) Q2 FY09 (1/09)	DSW	2
M19	Science & Engineering	Develop a resource-loaded plan for conducting DyNex experiments, including acquisition or manufacture of necessary materials, to support a decision by NA-10 whether to proceed.	LANL	Q2 FY04 (3/04)	Primary Certification	6
M20	LEPs	Complete the life extension refurbishment of the W87.	LLNL, Plants	Q3 FY04 (3/04)	DSW	5
M21	Science & Engineering	DARHT dual axis multi-pulse radiographic capability available to the National Hydrotest Program.	LANL, LLNL	Q2 FY05 (3/05)	Advanced Radiography	3
M22	ICF	Complete the first stewardship experiment on NIF	LLNL, LANL, SNL	Q4 FY04 (9/04)	ICF	3
M23	National Priorities	Define and begin implementation of a framework for developing advanced warhead concepts, including completion of 6.2/2a RNEP, to support the Nuclear Posture Review and the emerging needs of the DoD.	LANL, LLNL, SNL	Q4 FY05 (9/05)	DSW	4
M24	National Priorities	Complete transition to and maintain the capability to conduct underground nuclear testing within 18 months of the President's decision to conduct testing.	NV-BN LANL, SNL, LLNL	Q4 FY05 (9/05)	Primary Certification	8
M25	Science & Engineering	Complete and execute a full year of hydro tests as documented in the National Hydrotest Plan	LANL, LLNL	Q1 FY06 (12/05)	Primary Certification	3
M26	ASC	Document the requirements to move beyond a 100TF ASC computing platform to a petaflop platform	LANL, LLNL, SNL	Q1 FY05 (12/04)	ASC	3
M27	Science & Engineering	Provide pit lifetime estimates based on plutonium-spiked alloy.	LLNL, SNL	Q3 FY06 (6/06)	Enhanced Surveillance	

Table A-1. NA-10 Level 1 Milestones (continued)

M28	LEPs	Complete certification of a B61warhead with quantified design margins and uncertainties.	LANL, SNL	Q3 FY06 (6/06)	DSW	5
M29	LEPs	Complete the life extension refurbishment of the first production unit for the B61in accordance with the approved project baseline.	LANL, SNL, Plants	Q2 FY06 (3/06)	DSW	5
M30	Pits	Provide design, R&D, and documentation to support system requirements and alternatives for CD-1 approval on the Modern Pit Facility.	HQ	Q2 FY06 (2/06)	Pit Certification & Manufacturing	6
M31	LEPs	Complete certification of a W80-3 warhead with quantified design margins and uncertainties.	LLNL, SNL	Q2 FY06 (3/06)	DSW	5
M32	LEPs	Complete the life extension refurbishment of the first production unit for the W80-3 in accordance with the approved project baseline.	LLNL, SNL, Plants	Q2 FY06 (3/06)	DSW	5
M33	ASC	Develop, implement, and validate an initial physics/engineering capability in advanced ASCI simulations and benchmark for the W76 and W80 against legacy codes and experiments	LANL, LLNL, SNL	Q3 FY06 (2/06)	ASC	3
M34	ASC	Provide a 100TF Platform environment supporting to the tri-laboratory DSW & Campaign simulation requirements	LLNL	Q1 FY07 (12/06)	ASC	3
M35	ICF	Complete the first ZR stewardship experiment	SNL	Q3 FY07 (6/07)	ICF	3
M36	LEPs	Complete certification of a W76-1 warhead with quantified design margins and uncertainties.	LANL, SNL	Q4 FY07 (9/07)	DSW	5
M37	LEPs	Complete the life extension refurbishment of the first production unit for the W76-1 in accordance with the approved project baseline.	LANL, SNL, Plants	Q4 FY07 (9/07)	DSW	5
M38	Pits	Certification of a W88 warhead with a Los Alamos-manufactured pit using quantification of margins and uncertainties.	LANL	Q4 FY07 (9/07)	Pit Certification & Manufacturing	6
M39	Pits	Begin type 126 pit manufacturing capability at ten pits per year.	LANL	Q4 FY07 (9/07)	Pit Certification & Manufacturing	6
M40	Construction & Infrastructure	Complete the key requirements for CD4 approval of MESA.	SNL	Q2 FY10 (4/10)	Engineering Campaigns	7,1,3
M41	ICF	CD4 approval to begin NIF operations.	LLNL	Q4 FY08 (9/08)	ICF	7
M42	Construction & Infrastructure	Complete the key requirements for CD4 approval on the Tritium Extraction Facility.	SRS	Q4 FY08 (9/08)	Tritium Readiness	7,1
M43	National Priorities	Irradiated Tritium Producing Burnable Absorber Bar (TPBAR) delivered to the Tritium Extraction Facility.	SRS	Q4 FY08 (9/08)	Tritium Readiness	7,1
M44	ASC	Complete modern baseline of all enduring stockpile systems with ASC codes	LANL, LLNL, SNL	Q4 FY09 (9/09)	ASC	3
M45	ICF	Commence indirect-drive ignition experiments on the National Ignition Facility.	LANL LLNL SNL	Q1 FY13 (12/12)	ICF	3

ASCI's previous Level 1 milestones

Previous ASCI milestones (prior to FY2004) are identified with an ID label, the quarter in which they were to be completed, and a title. The ID label identifies the milestone, as seen in this example: "NA-0.1" is the first (".1") milestone to be completed in the area of Nuclear Applications ("NA") in the year 2000 ("0").

NUCLEAR APPLICATIONS

NA-0.1	FY00 Q1	Three-dimensional primary-burn prototype simulation
NA-0.2	FY00 Q4	Three-dimensional prototype radiation-flow simulation
NA-1.1	FY01 Q1	Three-dimensional secondary-burn prototype simulation
NA-2.1	FY02 Q1	Three-dimensional prototype full-system coupled simulation
NA-3.1	FY03 Q1	Enhanced primary physics initial capability
NA 3.2	FY03 Q1	Focused secondary physics capability at LLNL

NUCLEAR SAFETY

NS-2.1	FY02 Q4	Three-dimensional safety simulation of a complex abnormal explosive-initiation scenario
NS-3.1	FY03 Q2	Nuclear safety simulation of a complex abnormal explosive-initiation scenario

NONNUCLEAR APPLICATIONS

NN-0.1	FY00 Q2	Three-dimensional prototype hostile-environment simulation
NN-0.2	FY00 Q4	Architecture for coupled mechanics running at all NWC sites
NN-1.1	FY01 Q4	Mechanics for normal environments
NN-2.1	FY02 Q4	STS abnormal environment prototype simulation for crash and burn events
NN-3.1	FY03 Q4	STS hostile environment simulation for cable SGENP and electrical response to x-rays

VERIFICATION AND VALIDATION

VV-1.1	FY01 Q1	Establish and deploy a common set of acceptable software engineering practices applicable to all advanced application-development activities
VV-1.2	FY01 Q2	Demonstrate initial validation methodology on the then-current state of application modeling of early-time primary behavior
VV-2.1	FY02 Q4	Demonstrate initial validation methodology of the then-current state of ASCI code modeling for normal and abnormal STS environments behavior

PHYSICAL AND MATERIALS MODELING

PM-2.1	FY02 Q2	Microstructure-level shock response of PZT 95/5
PM-2.2	FY02 Q4	Delivery of initial macro-scale reactive flow model for high-explosive detonation derived from grain scale dynamics
PM-3.1	FY03 Q4	Meso-scale model for corrosion of electrical components

SIMULATION AND COMPUTER SCIENCE

SC-3.1	FY03 Q4	User environment for the Q platform at LANL

VIEWS

VU-0.1	FY00 Q1	Prototype system that allows weapons analysts to see and understand results from three-dimensional prototype primary-burn simulations

PSE

PS-1.1	FY01 Q1	Initial software development environment extended to the 10-teraOPS system

DisCom

DC-1.1	FY01 Q2	Distance-computing environment available for use on the 10- teraOPS ASCI system

Physical Infrastructure and Platforms

PP-0.1	FY00 Q3	10-teraOPS system (*White*), final delivery and checkout
PP-2.1	FY02 Q3	20-teraOPS system (*Q*), final delivery and checkout
PP-4.1	FY04 Q4	40-teraOPS system (*Red Storm*), final delivery and checkout

Appendix B

Performance Measures

Table B-1. ASCI Performance Measures for FY 2004-2009

PERFORMANCE GOAL: Predictive simulation and modeling tools, supported by necessary computing resources, to maintain long-term stewardship of the stockpile.						
PERFORMANCE INDICATORS*	ANNUAL PERFORMANCE TARGETS					
	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Peer-reviewed progress, according to schedule, toward a validated full-system, high-fidelity simulation capability	Complete sufficient milestones to achieve high-fidelity primary simulation and STS abnormal environments	Complete sufficient milestones to achieve high fidelity secondary simulation, Initial Validated (IV) STS hostile environment, IV high-fidelity physics primary, and Red Storm (40 teraOPS) user environment	Complete sufficient milestones to achieve IV focused, high-fidelity physics secondary, and Purple (100 teraOPS) user environment	Complete sufficient milestones to achieve IV STS normal	Complete sufficient milestones to achieve initial high-fidelity physics, full-system, coupled STS abnormal environment, and 200T user environment	Complete modern baseline of all enduring stockpile systems
Weapon system components, primary/secondary/ engineering system, analyzed using ASCI codes, as part of annual assessments and certifications process or LEPs	10 of 31	13 of 31	17 of 31	22 of 31	28 of 31	31 of 31
Amount of capability platform acquired	40 teraOPS 10TB 240TB	100 teraOPS 50TB 1PB	N/A	200 teraOPS 100TB 4PB	N/A	350 TeraOPS
Total capacity of ASCI production platforms taking into consideration procurements and retirements of systems	75 teraOPS	172 teraOPS	160 teraOPS	360 teraOPS	470 teraOPS	980 teraOPS

*** Footnote**

Appendix C

Risk Management

Risk management is a process for identifying and analyzing risks, encouraging mitigation and contingency planning to minimize potential consequences of identified risks, and monitoring and communicating up-to-date information about risk issues. Risk management is about identifying opportunities and avoiding losses.

A "risk" is defined as (1) a future event, action, or condition that might prevent the successful execution of strategies or achievement of technical or business objectives, and (2) the risk exposure level, defined by the likelihood or probability that an event, action, or condition will occur, and the consequences, if that event, action, or condition does occur. Table C-4 summarizes ASCI's top ten risks, which are managed and tracked.

ASCI risk management consists of three major components: Assessment, Handling/Mitigation, and Tracking.

Risk Assessment

Risk assessment involves identification, analysis, and mitigation/contingency planning. The objective of risk assessment is to prioritize risks, so management may focus efforts on mitigating top risk items. (See Table C-1 and Table C-2). There are five different ASCI risk types: Programmatic, Technical, Cost, Schedule, and Performance.

Risk Handling/Mitigation

Risk handling/mitigation is proactively undertaken to lessen consequence or likelihood, and/or develop contingency actions, in the event that risk issues develop. (See Table C-3.) There are four different risk-handling methods: Avoidance, Control, Assumption, and Risk Transfer.

Risk Tracking

Risk tracking involves tracking the progress and status of mitigation actions and of risks. Risk status and evaluations can be found in tri-lab quarterly progress reports, as well as DP status reports.

Table C-1 evaluates consequences against cost, performance, and schedule.

- *Cost Risks* – not enough money at the highest level to do the job required in the time allocated.
- *Performance Risks* – one or more performance requirements may not be met due to technical concerns, or issues of competence, experience, organizational culture, and management team skills.
- *Schedule Risks* – not enough time exists at the highest level to do the required job with the resources allocated.

Table C-1. Consequence Criteria

Consequence	Criteria
Very Low	**Cost:** Negligible impact on cost. Impact is contained within the strategic unit and results in neither under or over costing of spend plan. **Performance:** Negligible impact on function or performance. Requirements are clearly met. **Schedule:** Negligible impact on schedule. Impact is managed within the strategic unit. Results in no impact to critical path and no impact to other strategic units. Milestones are clearly met.
Low	**Cost:** Minor impact on cost. Impact is contained within the strategic unit and results in less than 5% under or less than 5% over costing of spend plan. **Performance:** Minor impact on function or performance. Requirements are clearly met. **Schedule:** Minor impact on schedule. Impact may be managed within the strategic unit. Results in no impact to critical path and no impact to other strategic units. Milestones are clearly met.
Moderate	**Cost:** Recognizable impact on cost. Impact is not contained within the strategic unit and may result in less than 5% under or greater than 5% over costing of spend plan. **Performance:** Recognizable impact on function or performance. Requirements may not all be met. **Schedule:** Recognizable impact on schedule. Impact may not be managed within the strategic unit. May result in impact to critical path or may impact other strategic units. Milestones may not be met.
High	**Cost:** Significant impact on cost. Impact is not contained within the strategic unit and may result in less than 10% under or greater than 10% over costing of spend plan. **Performance:** Significant impact on function or performance. Requirements will not all be met. **Schedule:** Significant impact on schedule. Impact will not be managed within the strategic unit. Will result in impact to critical path or will impact other strategic units. Milestones will not be met.
Very High	**Cost:** Major impact on cost. Impact will not be contained within the strategic unit and will result in less than 10% under or greater than 10% over costing of spend plan. **Performance:** Major impact on function or performance. Requirements cannot be met. **Schedule:** Major impact on schedule. Impact cannot be managed within the strategic unit. Will result in failure in critical path or will significantly impact other strategic units. Milestones cannot be met.

Table C-2 evaluates likelihood against programmatic or technical risks.

- *Programmatic Risks* – those risks that flow from or have an impact on program governance, and those risks that impact program performance.
- *Technical Risks* – performance risks associated with end items

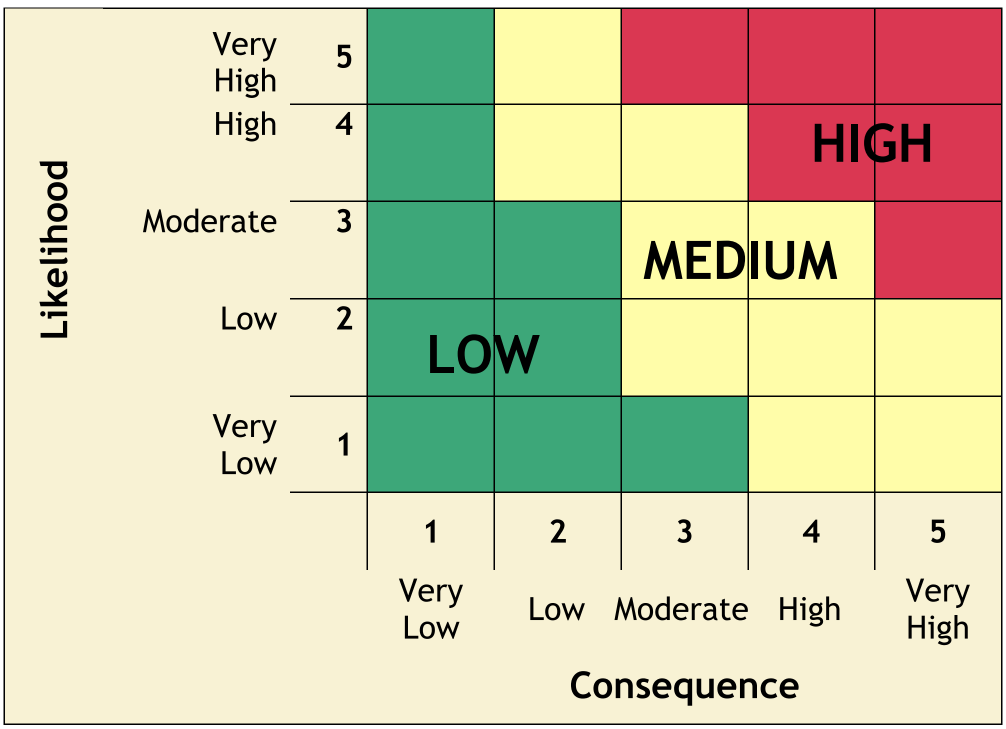
Table C-2. Likelihood Criteria

Likelihood	Criteria
Very Low	**Programmatic:** No external, environment, safety, and health (ES&H), security or regulatory issues. Qualified personnel, resources, and facilities are available. **Technical:** Non-challenging requirements. Simple design or existing design. Few and simple components. Existing technology. Well-developed process.
Low	**Programmatic:** Minor potential for external, ES&H, security or regulatory issues. Minor redirection of qualified personnel, resources, or facilities modification is necessary. **Technical:** Low requirements challenge. Minor design challenge or minor modification to existing design. Moderate number or complex components. Existing technology with minor modification. Existing process with minor modification.
Moderate	**Programmatic:** Moderate potential for external, ES&H, security or regulatory issues. Moderate redirection of qualified personnel, resources, or facilities modification is necessary. **Technical:** Moderate requirements challenge with some technical issues. Moderate design challenge or significant modification to existing design. Large number or very complex components. Existing technology with significant modification. Existing process with significant modification.
High	**Programmatic:** Significant potential for external, ES&H, security or regulatory issues. Significant redirection of qualified personnel, resources, or facilities modification is necessary. **Technical:** Significant requirements challenge with major technical issues. Significant design challenge or major modification to existing design. Large number and very complex components. New technology. New process.
Very High	**Programmatic:** Major potential for external, ES&H, security or regulatory issues. Major redirection of qualified personnel, resources, or facilities modification is necessary. **Technical:** Major requirements challenge with possibly unsolvable technical issues. Major design challenge or no existing design to modify. Extreme number and extremely complex components. Possibly no technology available. Possibly no process available.

Table C-3 evaluates risk exposure, based on consequence and likelihood. Different risk handling methods that relate to this exposure include:

- *Avoidance* – use an alternate approach, with no risks, if feasible. This approach can be applied to high and medium risks.
- *Control* – develop a risk mitigation approach/action and track the progress of that risk. This approach is mostly applied to high and medium risks.
- *Assumption* – accept the risk and proceed. This approach is usually applied to low risk items.
- *Risk Transfer* – pass the risk to another program element. This approach can be applied to external risks outside the control of ASCI program.

Table C-3. Risk Exposure Level Matrix



The risk exposure values and the resulting matrix categorize risks as high, medium, and low. When risk exposure is high, mitigating or contingency plan is required. When risk exposure is medium, mitigating or contingency plan is recommended. When risk exposure is low, developing some mitigating or contingency plan is optional. Table 2 details the risk exposure levels found in Table C-3, describing the risk, it's associated risk assessment and approach to mitigation.

Appendix D

Glossary

Advanced Applications	Element of DAM program area that provides physics and geometric fidelity for weapons simulations.
Advanced Architectures	An ASCI program element that is focused on development of more effective architectures for high-end simulation and computing.
Alliances	A program element within the University Partnerships.
ASCI	Advanced Simulation and Computing program. This program evolved from merging of the Accelerated Strategic Computing Initiative and the Stockpile Computing program. For historical reasons, the use of the acronym "ASCI" has continued, following this programmatic merger.
ASCI Blue Mountain	A Silicon Graphics, Inc. (SGI) system located at LANL. In 1998, ASCI Blue Mountain was installed as a 3.072-teraOPS-computer system.
ASCI Blue Pacific	An IBM system located at LLNL. In 1998, ASCI Blue Pacific was installed as a 3.89-teraOPS-computer system.
ASCI Integration	One of ASCI's five program areas.
ASCI Purple	The next ASCI system to be located at LLNL in 2005.
ASCI Red	An Intel system located at SNL. ASCI Red was the first teraOPS platform in the world when it was installed in 1998 (1.872 teraOPS). Processor and memory upgrades in 1999 converted ASCI Red to a 3.15 teraOPS platform.
ASCI Red Storm	A 40-teraOPS system, to be located at SNL, scheduled for delivery in FY 2004.
ASCI Q	A Compaq, now Hewlett-Packard (HP), system located at LANL. ASCI Q is a 20 teraOPS computer system, delivered in FY 2003.
ASCI White	An IBM system located at LLNL. In 2000, ASCI White was installed as a 12.3 teraOPS supercomputer system.
B&R	DP's budget and reporting classification codes.

Campaigns	An organization of SSP activities that are focused on scientific and engineering aspects that address critical capabilities, tools, computations, and experiments needed to achieve weapons stockpile certification, manufacturing, and refurbishment, now and in the future, in the absence of nuclear testing.
Capability/capacity systems	Terminology used to distinguish between systems that can run the most demanding single problems versus systems that manage aggregate throughput for many simultaneous smaller problems.
Computational Systems	Element of ICS program area that provides computational and data storage systems, along with the networking infrastructure.
COTS	Commercial-off-the-shelf, referring to technologies.
DAM	Defense Applications and Modeling, the program area that focuses on development of 3-D, physics-model based codes that are formally verified and validated.
DARHT	The Dual Axis Radiographic Hydrodynamic Test Facility at LANL will examine implosions from two different axes.
DisCom	Distance Computing and Communication, a program element within ASCI, focused on computing at a distant location, and data communications between geographically distant locations.
DOE	U.S. Department of Energy
DP	Defense Programs, one of the three major programmatic elements in NNSA.
DPIP	Defense Programs Integrated Plan
DSW	Directed Stockpile Work, those SSP activities that directly support the day-to-day work associated with the refurbishment and certification of specific weapons in the nuclear stockpile.
DVC	Data and Visualization Corridors provide capabilities to allow visualization and manipulation of massive scientific datasets.
EOS	Equation-of-state
ES&H	Environment, safety, and health
FY	Fiscal Year. The U.S. Government's fiscal year runs from October 1 through September 30.
HQ	Headquarters, referring to DOE/NNSA headquarters location

ICS Integrated Computer Systems, the program component that provides the computing platforms and centers.

I/O Input/output

Institutes A program element within the University Partnerships.

JASON A group of university professors who study national security issues, at the request of the Federal government.

LANL Los Alamos National Laboratory, a prime contractor for NNSA, located in Los Alamos, New Mexico, and operated by the University of California.

LCD Liquid crystal display monitor

LEP Life Extension Program

LLNL Lawrence Livermore National Laboratory, a prime contractor for NNSA, located in Livermore, California, and operated by the University of California.

M&PM Materials and Physics Modeling, element of DAM program area that develops models for physics, material properties, and transport processes.

M&S Modeling and simulation capability

MESA Microsystems and Engineering Sciences Application Facility, scheduled for construction at SNL-Albuquerque, will provide the design environment for nonnuclear components of a nuclear weapon.

NAS National Academy of Sciences

NIF National Ignition Facility

NNSA National Nuclear Security Administration, a semi-autonomous agency within DOE

OMB Office of Management and Budget

OPTL One Program/Three Labs

PART Program Analysis and Rating Tool

PC Personal computer

PI&P Physical Infrastructure and Platforms, element of ICS program area that acquires computational platforms to support the SSP.

PathForward	An ASCI program element that partners with industry to accelerate the development of critical technology leading to commercial products needed by ASCI.
Petabyte	10^{15} bytes; 1,024 terabytes
PetaOPS	1000 Trillion floating-point operations per second. PetaOPS is a measure of the performance of a computer.
PP	Program Plan
PSE	Problem Solving Environment, an ASCI program element focused on the development of an infrastructure that provides effective software development tools, production computing environments, and archival storage.
PZT	Lead zirconate titanate
R&D	Research and development
RAS	Reliable, available, secure
ROI	Return-on-investment
S&CS	Simulation and Computer Science, the program element that provided the infrastructure necessary to connect applications and platforms into integrated systems.
Science-based	The effort to increase understanding of the basic phenomena associated with nuclear weapons, to provide better predictive understanding of the safety and reliability of weapons, and to ensure a strong scientific and technical basis for future United States nuclear weapons policy objectives.
SFI	Significant Finding Investigation. An SFI results from the discovery of some apparent anomaly with the enduring stockpile. DSW Surveillance generally initiates an SFI. For complex SFI's, resolution comes from the Assessment & Certification element of DSW, often in partnership with ASCI capabilities.
SLEP	Stockpile Life Extension Program. SLEP is the DP element responsible for planning and execution of component and weapon refurbishments.
SNL	Sandia National Laboratories, a prime contractor for NNSA with locations primarily in Albuquerque, New Mexico, and Livermore, California, and operated by Lockheed Martin Corporation.
SSP	Stockpile Stewardship Program, DP's response to ensuring the safety, performance, and reliability of the U.S. nuclear stockpile.

STS	Stockpile-to-target sequence, a complete description of the electrical, mechanical, and thermal environment in which a weapon must operate, from storage through delivery to a target.
Terabyte	Trillions of bytes, abbreviated TB, often used to designate the memory or disk capacity of ASCI supercomputers. A byte is eight bits (binary digit, 0 or 1) and holds one ASCII character. (ASCII—the American Standard Code for Information Interchange.) For comparison, the book collection of the Library of Congress has been estimated to contain about 20 terabytes of information.
TeraOPS	Trillion floating-point operations per second. TeraOPS is a measure of the performance of a computer.
Test-based	The traditional approach used for the development of nuclear weapons, based on full-scale nuclear tests.
Tri-lab	Refers to the three NNSA laboratories: LLNL, LANL, and SNL.
University Partnerships	One of ASCI's five program areas.
V&V	Verification and Validation. Verification is the process of confirming that a computer code correctly implements the algorithms that were intended. Validation is the process of confirming that the predictions of a code adequately represent measured physical phenomena.
VIEWS	Visual Interactive Environment for Weapons Simulation. VIEWS is the ASCI program element that provides the capability for scientists and engineers to "see and understand" the results of a simulation.

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Issued by Sandia National Laboratories, a Department of Energy Laboratory operated by Sandia Corporation, a Lockheed Martin Company, under contract DE-AC04-94AL85000.

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"... With the advent of everyday use of elaborate calculations, speed has become paramount to such a high degree that there is no machine on the market today capable of satisfying the full demand of modern computational methods. The most advanced machines have greatly reduced the time required for arriving at solutions to problems which might have required months or days by older procedures. This advance, however, is not adequate for many problems encountered in modern scientific work and the present invention is intended to reduce to seconds such lengthy computations..."

From the ENIAC patent (No. 3,120,606), filed 26 June 1947.