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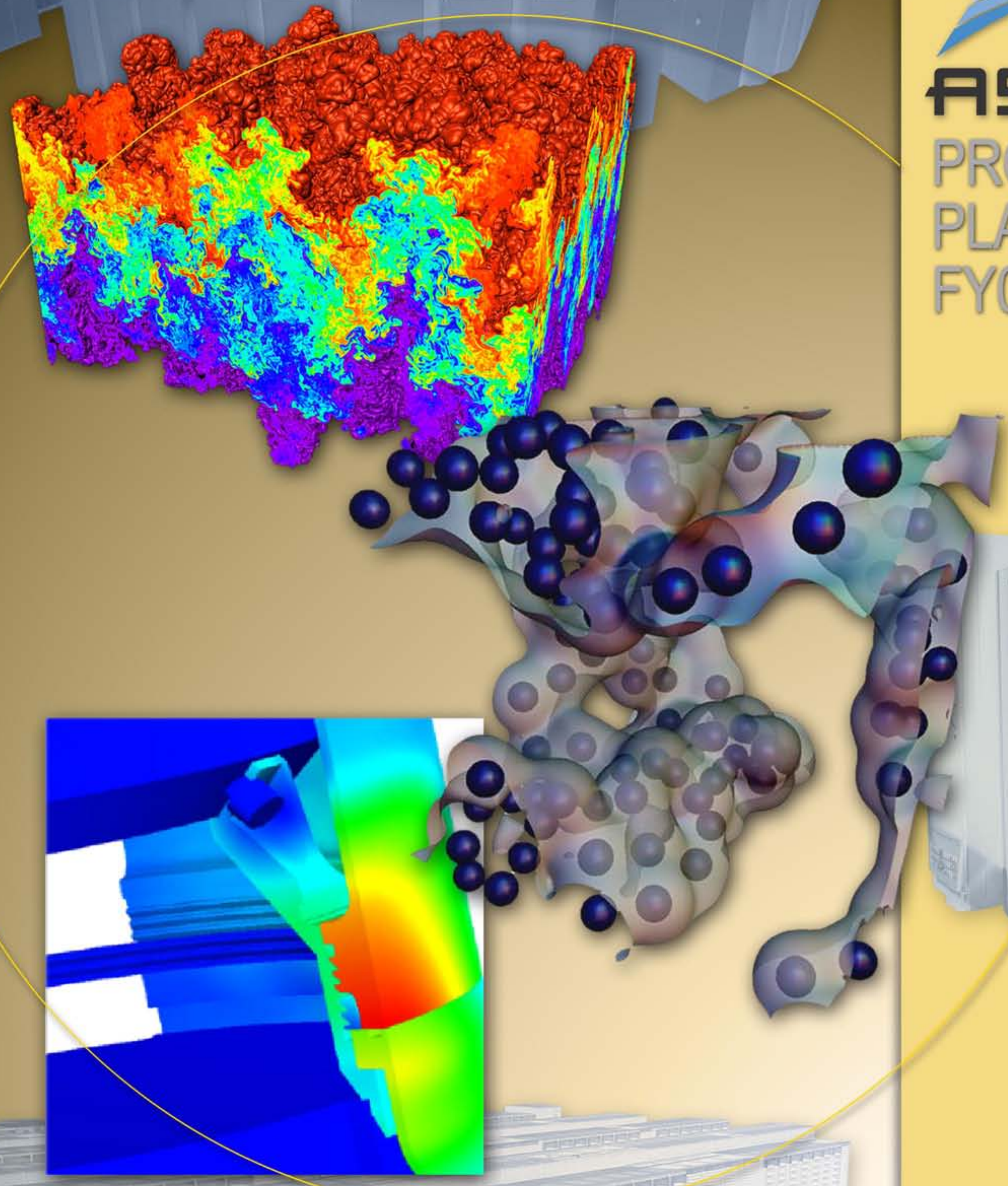

ASC™ PROGRAM PLAN FY05

National Nuclear Security Administration

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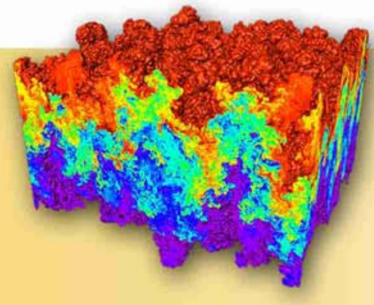
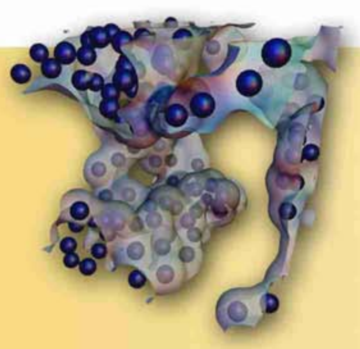
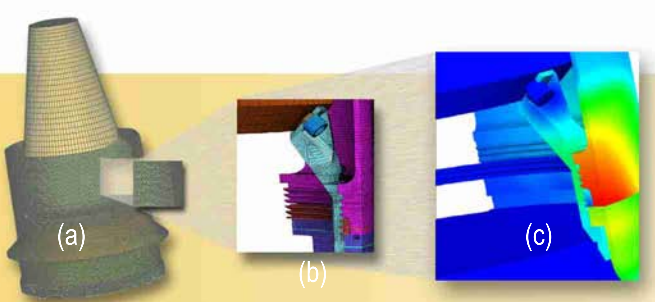


Rayleigh-Taylor instability and the Miranda code: The Miranda code was used by lab researchers to determine how two fluids of different densities mix together when the heavier fluid starts out above the lighter fluid.



Quantum molecular dynamics (QMD) calculation: QMD calculation results are shown in this visual of the electrical conductivity of aluminum as a function of material density. The complex structure of the electron density is depicted here. At lower density, where phase separation is pronounced, a gap begins to form at low energy. These types of ab-initio calculations are being used to develop improved electrical conductivity models in ALEGRA-HEDP, an ASC-funded, high energy-density physics code, used in simulating Z-pinch and other magneto hydrodynamic (MHD) phenomena.



Model validation and uncertainty quantification for simulating dynamics of complex mechanical interfaces: The W76 for forward mount (a) is modeled in detail (b) and then subjected to impulse loading (c) regions of high stress appear in red (featured on the cover). By analyzing experimental data and assessing model responses over a wide range of simulated events, developers refine and validate the model.

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Advanced Simulation and Computing

PROGRAM PLAN FY05

SEPTEMBER 2004

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Contents

Figures

Tables

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. The SSP uses past nuclear test data along with current and future nonnuclear test data, computational modeling and simulation, and experimental facilities to advance understanding of nuclear weapons. It includes stockpile surveillance, experimental research, development and engineering programs, and an appropriately scaled production capability to support stockpile requirements. This integrated national program will require the 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 (ASC)[1] is a cornerstone of the SSP, providing simulation capabilities and computational resources to support the annual stockpile assessment and certification, to study advanced nuclear-weapons design and manufacturing processes, to analyze accident scenarios and weapons aging, and to provide the tools to enable Stockpile Life Extension Programs (SLEPs) and the resolution of Significant Finding Investigations (SFIs). This requires a balanced resource, including technical staff, hardware, simulation software, and computer science solutions.

In its first decade, the ASC strategy focused on demonstrating simulation capabilities of unprecedented scale in three spatial dimensions. The next decade will focus on increasing the ASC predictive capabilities in a three-dimensional simulation environment while maintaining the support to stockpile stewardship. To achieve the goals, ASC must continue to meet three objectives:

Objective 1. Robust Tools

Develop robust models, codes, and computational techniques to support stockpile needs such as refurbishments, SFIs, LEPs, annual assessments, and evolving future requirements.

Objective 2. Simulation as a Predictive Tool

Deliver validated physics and engineering tools to enable simulations of nuclear-weapons performances in a variety of operational environments and physical regimes and to enable risk-informed decisions about the performance, safety, and reliability of the stockpile.

Objective 3. Balanced Operational Infrastructure

Implement a balanced computing platform acquisition strategy and operational infrastructure to meet Directed Stockpile Work (DSW) and SSP needs for capacity and high-end simulation capabilities.

This ASC Program Plan details the strategy and deliverables to accomplish the FY 2005–2010 multifaceted objectives, including program goals, strategies, and performance measures. Additionally, this plan includes ASC Level 1 milestones and the top ten risk items. To ensure synchronization with the SSP needs, the Program Plan will be reviewed and updated annually.

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[1] In FY 02 the Advanced Simulation and Computing (ASC) Program evolved from the Accelerated Strategic Computing Initiative (ASCI).

Introduction

The predecessor to ASC, the Accelerated Strategic Computing Initiative (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 lifetimes 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.

NNSA will carry out its responsibilities through the 21st century in accordance with the current Administration's vision and the Nuclear Posture Review (NPR) guidance. NNSA Administrator Ambassador Brooks summarized[2] the NNSA objectives for SSP as follows:

> *"We will continue to lead the way to a safer world through the deep reductions in nuclear forces codified by the Moscow Treaty, through Nunn-Lugar and other cooperative threat reduction efforts, and through other actions. At the same time, although conventional forces will assume a larger share of the deterrent role, we will maintain an effective, reliable, and capable—though smaller—nuclear force as a hedge against a future that is uncertain and in a world in which substantial nuclear arsenals remain. Our ongoing efforts to reduce the current stockpile to the minimum consistent with national security requirements, to address options for transformation of this smaller stockpile, and to create a responsive nuclear weapons infrastructure are key elements of the Administration's national security strategy. . . ."*

A truly responsive infrastructure will allow us to address and resolve any stockpile problems uncovered in our surveillance program; to adapt weapons (achieve a capability to modify or repackage existing warheads within 18 months of a decision to enter engineering development); to be able to design, develop, and initially produce a new warhead within three to four years of a decision to do so;[3] to restore production capacity to produce new warheads in sufficient quantities to meet any defense needs that arise without disrupting ongoing refurbishments; to ensure that services such as warhead transportation, tritium support, and other ongoing support efforts are capable of being carried out on a time scale consistent with the Department of Defense's ability to deploy weapons; and to improve test readiness (an 18-month test readiness posture) in order to be able to diagnose a problem and design a test that could confirm the problem or certify the solution (without assuming any resumption of nuclear testing).

The ASC Program plays a vital role in the NNSA infrastructure and its ability to respond to the NPR guidance. The program focuses on development of modern simulation tools that can provide insights into stockpile problems, provide tools with which designers and analysts can certify nuclear weapons, and guide any necessary modifications in nuclear warheads and the underpinning manufacturing processes. Additionally, ASC is enhancing the predictive capability necessary to evaluate weapons effects, design experiments, and ensure test readiness.

ASC continues to improve its unique tools to solve progressively more difficult stockpile problems, with a focus on sufficient resolution, dimensionality, and scientific details, to resolve the increasingly difficult analyses needed for stockpile stewardship. ASC is advancing leading-edge technology in high-performance computing and predictive simulation to meet the short-term and long-term SSP needs [including the annual assessments and certifications, Life Extension Programs (LEPs), and Significant Finding Investigations (SFIs)]. The following section lists past, present, and planned ASC contributions to meet these needs.

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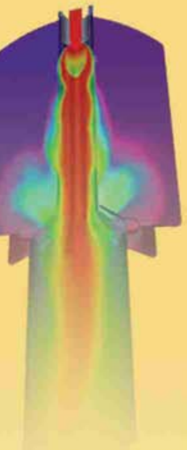
[2] Speech presented to the Heritage Foundation Conference: *U.S. Strategic Command: Beyond the War on Terrorism*, May 12, 2004.

[3] While there are no plans to develop new weapons, gaining the capability is an important prerequisite to deep reductions in the nuclear stockpile.

ASC Contributions to the SSP

- **In FY 1996**, ASCI Red was delivered. Red, the world's first teraOPS supercomputer, has since been upgraded to more than 3 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 three dimensional (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-system (primary and secondary) thermonuclear weapon explosion, and ASCI completed the 3-D analysis for an 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 weapons system in a hostile (nuclear) environment; and ASCI delivered an operational 20-teraOPS platform on the ASCI Q machine.
- **In FY 2004**, ASC provided simulation codes with focused model validation to support the annual certification of the stockpile and to assess manufacturing options. These efforts will continue beyond FY 2009. ASC supported the life-extension refurbishments of the W76 and W80, in addition to the W88 pit certification. In addition, ASC provided the simulation capabilities to design various nonnuclear experiments and diagnostics.
- **In FY 2005**, ASC will identify and document SSP requirements to move beyond a 100-teraOPS computing platform to a petaOPS-class system; ASC will deliver a metallurgical structural model for aging to support pit-lifetime estimations, including spiked-plutonium alloy. In addition, ASC will provide the necessary simulation codes to support test readiness as part of the NNSA national priorities.
- **By FY 2006**, ASC will develop, implement, and validate an initial physics and engineering capability in advanced ASC simulations for the W76 and W80, benchmarked against legacy codes and experiments; ASC will support the completion of the B61 and W80-3 warhead certifications, using quantified design margins and uncertainties; and ASC will provide a basic 100-teraOPS-platform user environment supporting the SSP requirements. ASC will provide data for model development and Verification and Validation (V&V) to support hydro test activities, as defined in the National Hydrotest Plan; ASC will provide the integrated codes to assess manufacturing options and impacts to support the CD-1 approval of the Modern Pit Facility. In addition, ASC will support the life-extension refurbishment of the first production unit for the W80-3.
- **By FY 2007**, ASC will support the completion of the W76-1 warhead certification, using quantified design margins and uncertainties; ASC will also provide a robust 100-teraOPS-platform production environment supporting Directed Stockpile Work (DSW) and Campaign simulation requirements. In addition, a high-capability platform will be sited at Los Alamos National Laboratory (LANL).
- **By FY 2008**, ASC will deliver the codes for experiment and diagnostic design to support the CD-4 approval on the National Ignition Facility (NIF).
- **By FY 2009**, a modern baseline of all enduring stockpile systems, using ASC codes, will be completed.
- **In FY 2013** and beyond, ASC will continue to deliver codes for experiment and diagnostic design to support the indirect-drive ignition experiments on the NIF.



Mission

Provide leading edge, high-end simulation capabilities needed to meet weapons assessment and certification requirements

To meet the above mission and enhance the ability of the SSP to respond to stockpile needs in FY 2005–2010, ASC will:

- Continue supporting the immediate stockpile needs, including the annual assessments and certifications, LEPs, and SFIs.
- Advance the development of ASC codes to provide the increased predictive capability necessary to understand aging phenomena that push our current science-based tools outside tested regimes.
- Stimulate the U.S. computer-manufacturing industry to create the powerful high-end computing capability required by the SSP.
- Expand computational infrastructure and operating environment to enable better accessibility and usability of ASC capabilities.
- Enhance integration with the Science Campaigns to develop and incorporate improved, validated physics and materials models into the ASC codes.

Vision

Predict, with confidence, the behavior of nuclear weapons, through comprehensive, science-based simulations

ASC will further enhance both the science and technology necessary to accomplish the above vision by integrating with Science Campaigns and DSW to develop better science models; incorporating enhanced physics models into the simulation codes; delivering robust codes with enhanced computational techniques; applying verification and validation methodologies early in the modern code-development process; and providing leading-edge technology in the platforms and operating environments necessary for executing complex science-based simulations.

Goals

Deliver increasingly accurate simulation and modeling tools, supported by necessary computing resources, to sustain the stockpile

Development and implementation of comprehensive methods and tools for certification, including 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.*[4]

To ensure its ability to respond to stockpile needs and deliver accurate simulation and modeling tools, ASC has three major objectives to address both the short- and long-term components of the SSP:

Objective 1. Robust Tools

Develop robust models, codes, and computational techniques to support stockpile needs such as refurbishments, SFIs, LEPs, annual assessments, and evolving future requirements.

Objective 2. Simulation as a Predictive Tool

Deliver validated physics and engineering tools to enable simulations of nuclear-weapons performances in a variety of operational environments and physical regimes and to enable risk-informed decisions about the performance, safety, and reliability of the stockpile.

Objective 3. Balanced Operational Infrastructure

Implement a balanced computing-platform acquisition strategy and operational infrastructure to meet SSP needs for capacity and high-end simulation capabilities.

Strategy

In its first ten years, the ASC Program followed a strategy that emphasized the development and use of high-fidelity, 3-D codes to address stockpile issues, and the creation and deployment of the required computational capabilities and supporting infrastructure. The success of ASC was demonstrated through a series of pioneering proof-of-principle milestone calculations. For the next decade, ASC has adopted a new strategy that emphasizes a continual reduction in the phenomenology in the weapons simulation codes and a deeper understanding, in quantitative terms, of their limitations in order to enable risk-informed decisions about the performance, safety, and reliability of the stockpile.

The ASC Program and the other Science Campaigns will be integrated with structured certification methodologies, including as an inherent element, the ability to assess and quantify the confidence in the use of ASC tools to make predictions and inform stockpile-related decisions. Developing the tools to address new concepts and options is another motivator that leads to this new strategy, guiding the transition from a successful initiative toward a more powerful and demonstrably predictive capability.

The ASC strategy has, and will continue to have, both short- and long-term components. These elements are not separable, but complementary and interdependent. The goal of the short-term component is to meet the continuing and time-constrained needs of stockpile stewardship, in particular, SFIs and life-extension activities. Addressing these needs as the properties of the devices in the stockpile change will force a transition to the modern codes with their increased

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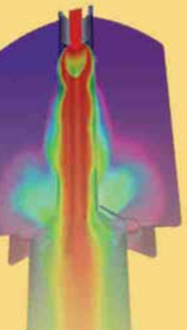
[4]Source: DP Program Planning and Resource Call Guidance



dimensionality and enhanced modeling capabilities. The fidelity of these codes will continue to be improved so that they become increasingly able to address any potential stockpile problems that may be uncovered in the surveillance process.

The long-term component of the strategy is to ensure movement toward reduced phenomenology to enhance confidence. It has been understood since the inception of computing in the weapons program that codes cannot be built and then accepted "on faith." To ensure that they are grounded in physical reality and form a basis for scientifically based decisions, the representation of weapons behavior must be supported by an increased focus on both verification and validation. As new models are incorporated into the codes, they can be rigorously tested against appropriate experiments to validate that they conform to physical reality. This strategy emphasizes a strengthened program of validation and peer review to quantify and then expand the parameter space currently spanned by older codes.

The products of ASC serve as the integrators for all aspects of the nuclear weapons enterprise, from assisting the plants in their manufacturing mission through the full stockpile life cycle, to understanding the provenance of crude terrorist devices, to a consideration of advanced concepts. The strategy described here will allow ASC to support the objectives articulated by Ambassador Brooks (see Introduction above).

ASC Level 1 Milestones

Level 1 milestones specific to ASC (Table 1) are designed to track ASC's progress toward accomplishing its strategic goals, 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 ASC Level 1 milestones. Appendix A lists all Defense Program, NA-10, Level 1 milestones, including ASC, which must be accomplished to meet the SSP mission.

Table 1. ASC Level 1 Milestones and Interfaces with DP Components for FY 2005–2010

Milestone	Responsible Laboratory	Date	Input Entity	Capability to be Delivered from Input Entity
Document requirements to move beyond a 100-teraOPS ASC 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 ASC simulations and benchmark for 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 100-teraOPS 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 ASC codes	**LANL, LLNL, SNL**	FY09 Q4	DSW	System descriptions for simulation input; stockpile issues to be addressed; test data for validation

*Campaign 1 (Primary Certification)
**Campaign 2 (Dynamic Materials)
***Campaign 4 (Secondary Certification & Nuclear Systems)

ASC Components

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

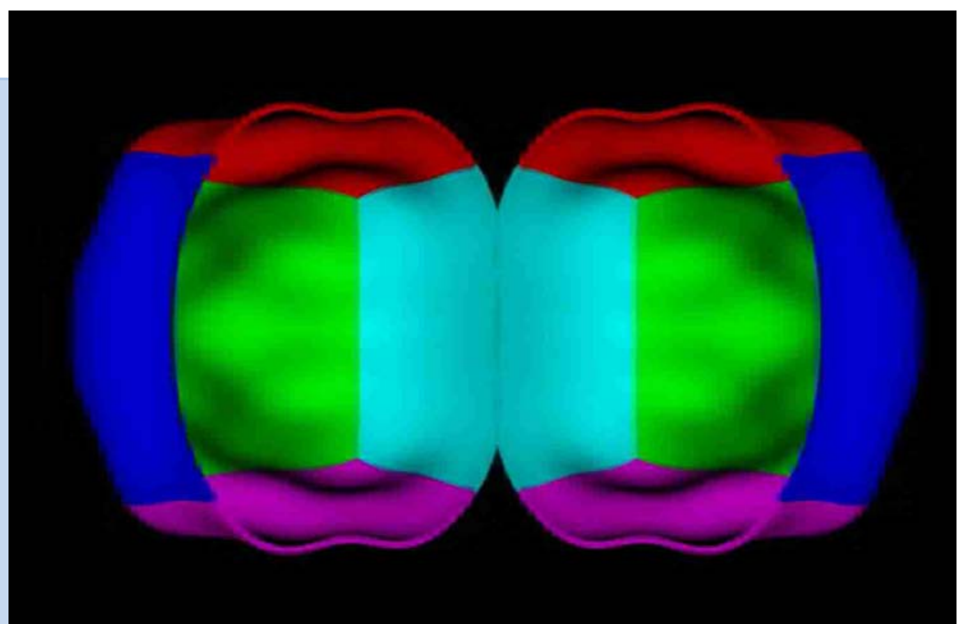
Defense Applications and Modeling (DAM)

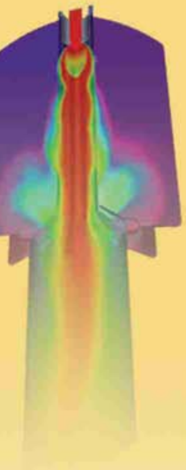
This program area develops and maintains all weapons codes used to support stockpile stewardship needs, including weapons design and assessments, accident analyses, certification issues, and manufacturing-process studies. The development of full-system codes requires new physics and materials models (see Figure 1), 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, Verification and Validation (V&V), and Physics and Materials Modeling (P&M).

To meet the overall ASC strategy, the DAM strategy focuses on improved models in the modern codes, delivery of validated tools, and response to SSP issues (e.g., SFIs, LEPs, annual assessments). Key drivers are to improve the confidence in prediction through simulations; to calculate, measure, and understand the uncertainty in the predictions; and to ensure rapid delivery of simulation capabilities to stockpile stewardship. The adequacy of this strategy will be assessed according to the following performance indicators (see Appendix B):

- Peer-reviewed progress in completing milestones, according to schedule in the ASC Campaign Program Plan, in the development and implementation of improved models and methods into integrated weapons codes and deployment and implementation of improved models and methods into integrated weapons codes and deployment to their users.
- Cumulative percentage of the 31 weapons system components, primary/secondary/engineering system, analyzed using ASC codes, as parts of annual assessments and certifications

Figure 1. Computer simulation of an imploding spherical shell. The shell is opened to show the initial perturbations on the inner and outer surfaces. Comparing the analytic solution of this problem with output from the computer simulation is one method we use to verify our simulation codes





Advanced Applications

Advanced Applications develops highly capable 2-D and 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 ASC elements, particularly the physics and materials models being developed and validated.

Elements of the strategy for Advanced Applications include:

- Developing the capability to meet the highest priority DSW simulation needs.
- Focusing on coupling of multiple physics models for end-to-end simulations, with a minimum of empirical calibration and designer tuning.
- Integrating physics and numerical methods for treating complex geometries in 2-D and 3-D computer codes.
- Developing the capability to simulate effects of replacement components as well as to analyze various STSs and nuclear surety.
- Designing and implementing improved numerical algorithms as well as incorporating improved physics models in the codes.
- Accelerating code performance by developing, analyzing, and modifying new algorithms and techniques.

Verification and Validation (V&V)

This program element establishes a technically rigorous foundation of credibility for the computational science and engineering calculations required by the SSP by developing science-based multidisciplinary processes to determine the adequacy of the simulations in delivering high-confidence predictive results. This program element combines verification activities to assess the code precision in implementing numerical approximations and attempts to assess the correctness of these solutions; validation activities to understand and assess the accuracy of the models by comparing with experimental data; quantification of the uncertainty of the simulations; and software quality engineering to institute sound software engineering practices and to ensure robust, efficient, and well-documented software releases of the ASC codes.

Elements of the strategy for V&V include:

- Aligning V&V efforts with the stockpile priorities in certification, SFIs, and LEPs.
- Increasing focus on uncertainty quantification methods to provide the basis by which computational uncertainties are evaluated and assessed.
- Increasing efforts to develop common verification and validation test suites to examine the adequacy and correctness of the ASC models and codes.
- Identifying requirements for, and compare calculations against, experimental validation data obtained through the experimental Science Campaigns.
- Providing 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.
- Developing and maintaining repositories of V&V products, including data, test results, and analyses, to be accessible to the Stockpile community.
- Applying software quality standards stemming from customer or regulator requirements and improving software engineering tools and practices for application to ASC simulations.

Physics and Materials Modeling (P&M)[5]

This program element develops models for physics, materials 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 P&M include:

- Developing equation-of-state (EOS) and constitutive models for weapons-relevant materials, including phase diagrams and dynamic response.
- Developing physics-based models predicting the properties of plutonium as it ages as a result of self-irradiation.
- Developing 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.
- Developing physics-based models for corrosion, polymer degradation, and thermal-mechanical fatigue of weapons electronics.
- Developing physics-based models of melting and decomposition of foams and polymers in safety-critical components.
- Developing 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 ASC platforms available to weapons scientists and analysts. This infrastructure includes wide-area networks that allow remote users to run applications securely, software tools for application development and execution tailored to ASC supercomputer architectures, and advanced scientific visualization and data analysis (see Figure 2) 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 Data and Visualization Science[6] (DVS).

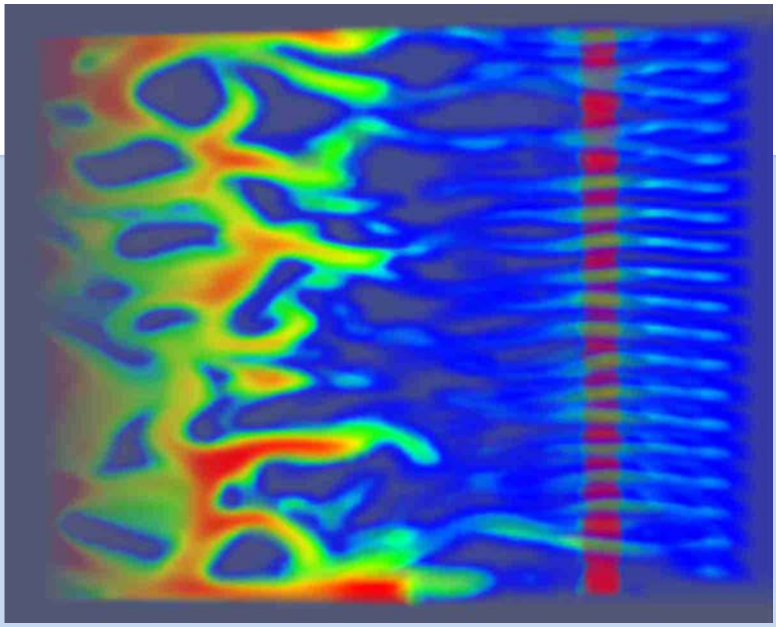


Figure 2. A view of an unstructured volume rendering, captured from ParaView, of an ALEGRA-HEDP simulation involving one wire in a 30-wire periodic wire array.

The combination of mass ablation due to electrical heating and magnetic forces about the wire (the red post-like structure on the right) causes wire material to ablate non-uniformly from the wire, traveling inside of the array (toward the left of the image) before array stagnation. Non-uniform mass ablation from wires is seen experimentally and is believed to significantly impact the net radiated power from Sandia's Z machine.

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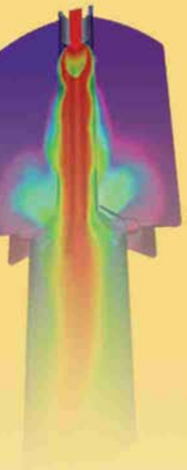
[5]Starting in mid FY04, the name of this program element was changed from Materials and Physics Modeling (M&PM) to Physics and Materials Modeling (P&M) to properly align with the program work breakdown structure and FY05–06 implementation plan.

[6]Starting in mid FY04, the name of this program element was changed from Visual Interactive Environment for Weapons Simulation (VIEWS) to Data and Visualization Science (DVS) to properly reflect the scope of the DVS Program.



The S&CS strategy is to balance DP laboratories, 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 Integrated Computer Systems (ICS), respectively. Based on S&CS technology roadmaps that emphasize ASC scalability needs, S&CS software tools and environments are developed to provide the best interface between the ASC platform and ASC applications. The adequacy of this strategy will be assessed according to the following performance indicator (see Appendix B):

- Peer-reviewed progress, according to schedule, in the ASC Campaign Program Plan, in the development and implementation of the improved models and methods into integrated weapons codes and deployment to their users. (Long-term output.)

Problem Solving Environment (PSE)

The PSE program element develops a computational infrastructure that allows the efficient execution of applications on ASC 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 ASC 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 ASC supercomputers and other ASC resources across the three weapons laboratories.

Elements of the strategy for PSE include:

- Creating a common, usable, and robust application-development and execution environment for ASC computing platforms and ASC-scale applications, enabling code developers to meet the computational needs of weapons scientists and engineers readily.
- Producing an end-to-end, high-performance I/O, networking-and-storage archive infrastructure encompassing ASC platforms and operating systems, large-scale simulations, and data-exploration capabilities to enable efficient ASC-scale computational analysis.
- Ensuring secure, effective access to "initial delivery" and "general availability" ASC supercomputers, as well as to other ASC resources, across the three NNSA national laboratories such that ASC'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, very-high-speed, remote access to tri-lab users of ASC supercomputers to create a computing environment that appears local to the remote user to the extent possible. Secure computing at a distance is necessary for the three laboratories to access all ASC 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 DVS elements, to integrate services and security functions necessary for efficient remote access. In addition, DisCom aims to enable high-performance ASC computing at the Y-12 and Kansas City Plant.

Elements of the strategy for DisCom include:

- Developing and maintaining a wide-area infrastructure (links and services) that enables distant users to operate on remote computing resources as if they were local (to the extent possible).
- Providing a reliable, available, secure (RAS) environment for distance computing, through system monitoring and analysis, modeling and simulation, and technology infusion.

- Developing and implementing 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.
- Enabling remote access to ASC 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 ASC-class computer systems.

Elements of the strategy for PathForward include:

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

Data and Visualization Sciences (DVS)

The DVS programmatic goal is to create and deliver high-performance data and visualization environments in which massive quantities of data flow easily to user desktops and collaborative workspaces and through which scientists and engineers can absorb and exploit such data. DVS focuses on "consolidating, visualizing, and comprehending" the results of multi-teraOPS physics simulations and comparing results across simulations and between simulation and experiment to improve the predictive capabilities of ASC applications and models. DVS tasks include research and development, testing and evaluation, and production deployment.

Elements of the strategy for DVS include:

- Developing and deploying high-performance tools and technologies to support visual and interactive exploration of massive, complex data; effective data management, extraction, delivery, and archiving; and efficient remote or collaborative scientific data exploitation.
- Developing and deploying scalable data manipulation and rendering systems that leverage inexpensive, high-performance commodity graphics hardware.
- Developing and deploying high-capability office display access to data by leveraging high-bandwidth networks and low-cost, high-performance commodity desktops.
- Collaborating closely with academia and industry to focus and leverage technology development with a specific emphasis on scalability.
- Providing user training, hands-on classes, and tool documentation to support designers, analysts, and code developers.

Integrated Computing Systems (ICS)

Meeting ASC's program requirements for developing advanced applications requires not only large, complex application codes that drive the scale of computing machinery, but also the infrastructure that supports these large systems and simulations. The ICS goal is to develop and provide these computing resources and the infrastructure and to ensure that applications run productively with excellent cost performance on the most appropriate machines at any given time, end-to-end, and from input to data analysis and visualization to archiving the results. The ICS architecture continues to evolve as platforms, networks, archival storage, and visualization facilities change or are replaced. 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, Computational Systems, Simulation Support, and Advanced Architectures.

To accommodate the increased focus on predictive capability taking place through the ASC strategy, ICS acquires powerful ASC 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 (see Appendix B):

- The maximum individual platform computing capability delivered, measured in teraOPS.
- Total capacity of ASC production platforms attained, measured in teraOPS taking into consideration procurements and retirements of systems.

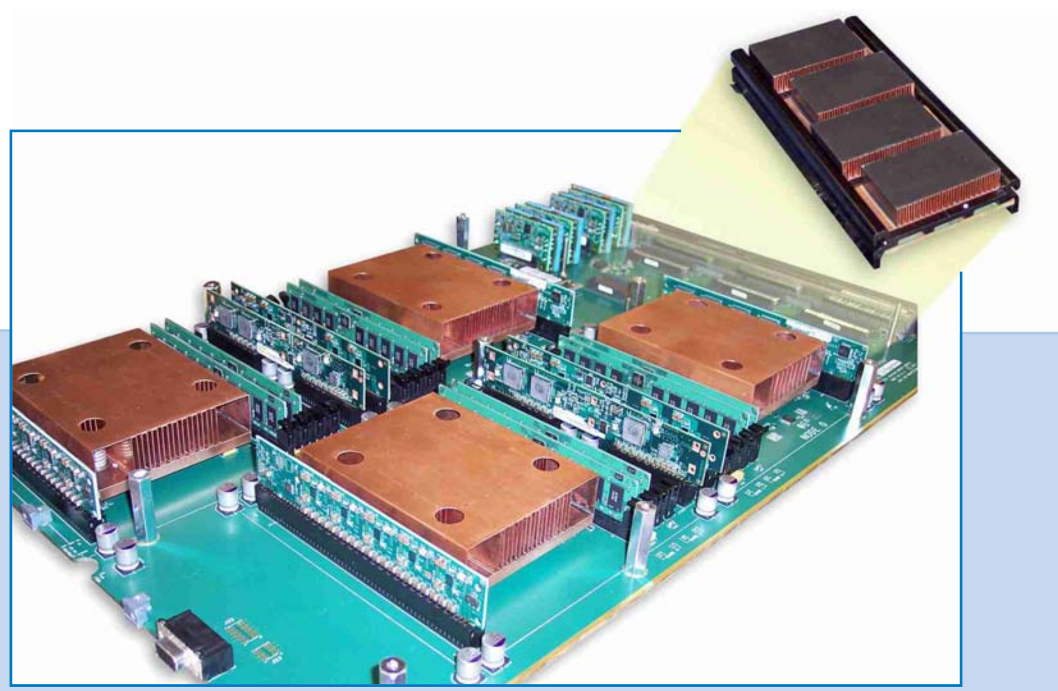


Figure 3. Shown here is a Cray, Inc., Red Storm compute module in manufacturing - with 4 AMD Opteron™ processors, and memory and power regulation components. The insert shows Cray SeaStar™ I/O subassembly.

Physical Infrastructure and Platforms (PI&P)

The PI&P program element acquires computational platforms to support the SSP. The 40-teraOPS Red Storm system at Sandia National Laboratories (SNL) will be completed in FY 2005.[7] The 100-teraOPS ASC Purple platform is scheduled for full delivery and installation at Lawrence Livermore National Laboratory (LLNL) in FY 2005,[8] with an early technology demonstration system in FY 2004. Current ASC program planning indicates that a 200-teraOPS platform will be sited at Los Alamos National Laboratory (LANL) in FY 2007. A final decision on the sizing and timing of that platform, and future machines, awaits the results of a comprehensive review of stockpile and science drivers for simulation, being defined by the ASC Level 1 milestone to be completed in FY 2005/Q1.

In addition to platforms being procured for production-computing environments for classified weapons work, the ASC Program has invested in a promising computer and computational-science research platform to be delivered to LLNL in FY 2005/Q1. The platform, named Blue Gene/L, came to market as a result of the ASC Advanced Architectures Program and was acquired as part of the Purple procurement.

Elements of the strategy for PI&P include:

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

Computational Systems[9]

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:

- Deploying ASC platforms as they are acquired.
- Providing system management of the laboratory ASC computers.
- Deploying and supporting the necessary networks and archives for laboratory computers.

Simulation Support

Simulation Support provides support services for computing, data storage, networking, and their users, 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:

- Operating and maintaining laboratory facilities that house ASC computers.
- Operating laboratory ASC computers and support integration of new systems.
- Providing analysis and software environment development and support for laboratory ASC computers.
- Providing user services and help desks for laboratory ASC computers.

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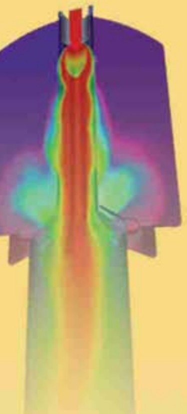
[7]Provide operational 40 teraOPS platform environment supporting the tri-lab DSW and Campaign simulation requirements by FY 2006.

[8]Provide operational 100 teraOPS platform environment supporting the tri-lab DSW and Campaign simulation requirements by FY 2007.

[9]This program element was previously part of Ongoing Computing, which was split in early FY04 into two new elements, Computational Systems and Simulation Support, to provide better programmatic visibility and understanding of driving factors and trends for ASC computing center costs.



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 ASC platforms more capable and cost effective. By working directly with high-end computing resource providers, this element allows these providers to explore innovative and novel solutions that could potentially address ASC's demanding computing requirements.

Elements of the strategy for Advanced Architectures include:

- Stimulating research and development efforts through advanced architectures that explore alternative computer designs, promising dramatic improvements in performance, scalability, reliability, packaging, or cost.

University Partnerships

This program area focuses on the advancement of research initiatives in computational sciences in support of the ASC Program, and in partnerships with U.S. academic institutions (see Figure 4) to educate and recruit individuals with skills critical to ASC. These activities help establish and validate large-scale multi-disciplinary modeling and simulation as a viable scientific approach. This program area is composed of the Academic Strategic Alliance Program, ASC Institutes, and Graduate Fellowships.

Academic Strategic Alliance Program

The Academic Strategic Alliance Program (ASAP) engages the U.S. academic community in making significant advances in science-based modeling and simulation technologies. Research conducted through this partnership contributes to the knowledge base required to demonstrate the capabilities of modeling and simulation across a broad spectrum of science and engineering applications using some of the most powerful computers in the world. The ASAP encourages collaboration between the national laboratories and universities in the advancement of science-based multi-disciplinary modeling and simulation technologies, and educating and recruiting individuals with skills critical to the ASC Program.

Elements of the strategy include:

- Solving science and engineering problems of national importance using large-scale, multidisciplinary modeling and simulation.
- Establishing and validating large-scale, multidisciplinary modeling and simulation as a viable scientific methodology across stewardship-related applications (i.e., those requiring coupled multi-physics and complex simulation sequences).
- Enhancing the overall ASC effort by engaging academic experts in computer science, computational mathematics, and simulation science and engineering fields of interest.
- Leveraging relevant basic science, high-performance computing systems, and problem-solving environment research in the academic community.
- Strengthening education and research in areas critical to the long-term success of ASC and the SSP.
- Strengthening ties among the Defense Programs laboratories and U.S. universities.

Institutes

The ASC Program supports an Institute at each of the three Defense Program laboratories to advance basic and applied research initiatives in computational sciences in support of the ASC Program. These ASC Institutes attract university experts to work with laboratory staff in research initiatives, and serve as focal points for laboratory-university interactions in support of the ASC Program.

Elements of the strategy for Institutes are:

- Enabling cutting-edge research activities relevant to the ASC Program in computer science, scientific computing, and computational mathematics at the laboratories.
- Engaging researchers in academia to collaborate with laboratory scientists in the exploration of challenging computer/computational problems.
- Establishing visitor programs for students and faculty to increase awareness of the research areas of interest to the laboratories.

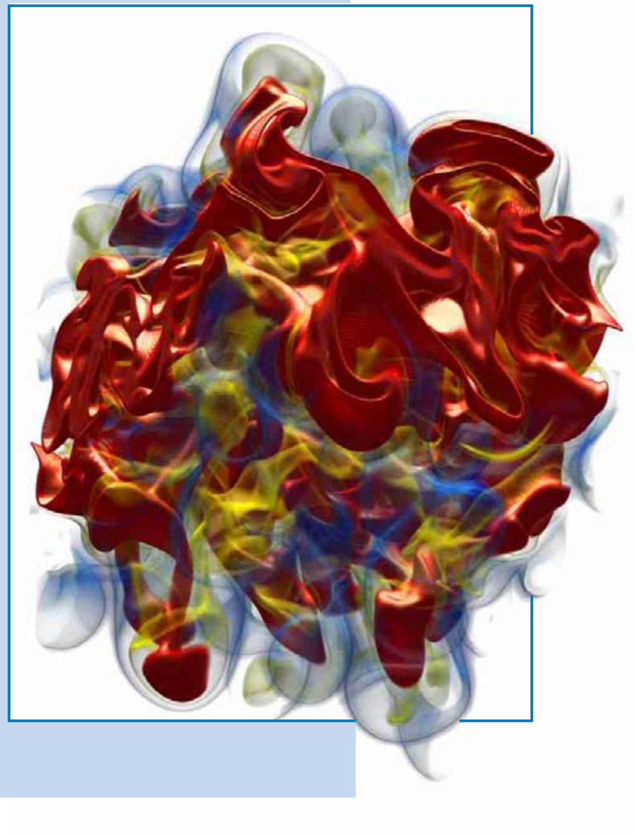
Fellowships

Recognizing the scarcity of U.S. citizens enrolling for advanced degrees in fields crucial to the success of ASC, two complementary Fellowship programs, both administered by the Krell Institute, are supported.

Elements of the strategy for this element are seen in two fellowships:

- The Computational Science Graduate Fellowship, funded jointly by the DOE Office of Science, supports highly capable individuals pursuing doctorates in basic and applied science or engineering disciplines with applications in high-performance computing. A practicum working with researchers at one of DOE's Office of Science or NNSA/DP laboratories is required of every fellow for at least one three-month period during the term of the fellowship.
- The High Performance Computer Science Fellowship supports highly qualified U.S. citizens pursuing a Ph.D. in computer science with an emphasis on high-performance computing. Fellows participating in the program are required to do at least one practicum (usually for three months) at an NNSA/DP laboratory.

Figure 4. This visualization was created using the teravoxel volume rendering cluster, based on the VP1000 volume rendering cards. The data set is a simulation of the Rayleigh-Taylor instability, as performed on a 256 x 256 x 1024 grid, both at Lawrence Livermore National Lab and at Caltech.

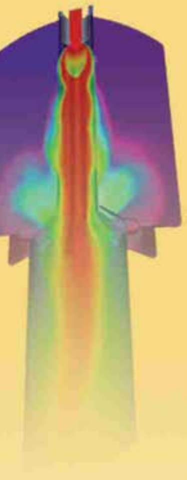


Integration Program

This program element integrates specific efforts that are not covered by the technical program elements. Integration includes One Program/Three Labs (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 ASC Program.

Elements of the strategy for the Integration Program include:

- Operating ASC as a single tri-lab program activity, with seamless management and execution across the laboratories.
- Sponsoring annual principal investigator meetings.
- Encouraging collaboration on initiatives and share hardware and software resources.
- Attending external technical and scientific related workshops and meetings.



Integration

Continual collaboration among ASC, Campaigns, and DSW is a major strength of the SSP. (Figure 5 exemplifies the use of ASC codes to perform simulations funded by Campaign 10, ICF.) Joint efforts in software development, code verification and validation, and tool-suite application are good examples of this collaboration.

- *Software Development –* ASC code project priorities are guided and coordinated with designers, via specific tasks and schedules, to meet DSW requirements and thereby accommodate weapons systems' modifications as part of the SLEPs.
- *Code Verification and Validation –* The verification and validation of ASC codes is conducted by ASC and DSW as part of the formal stockpile stewardship V&V process. Experiments 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 ASC simulation and modeling tool suite to assess unresolved surveillance SFIs by using 3-D simulations and new numerical techniques in the ASC 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 ASC tools and technologies to address physics and engineering issues associated with the W88, W76, W78, 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 ASC simulations. This reduction in development tests allowed acceleration of the development schedule and an improved allocation of existing resources.
    - ♦ ASC 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.

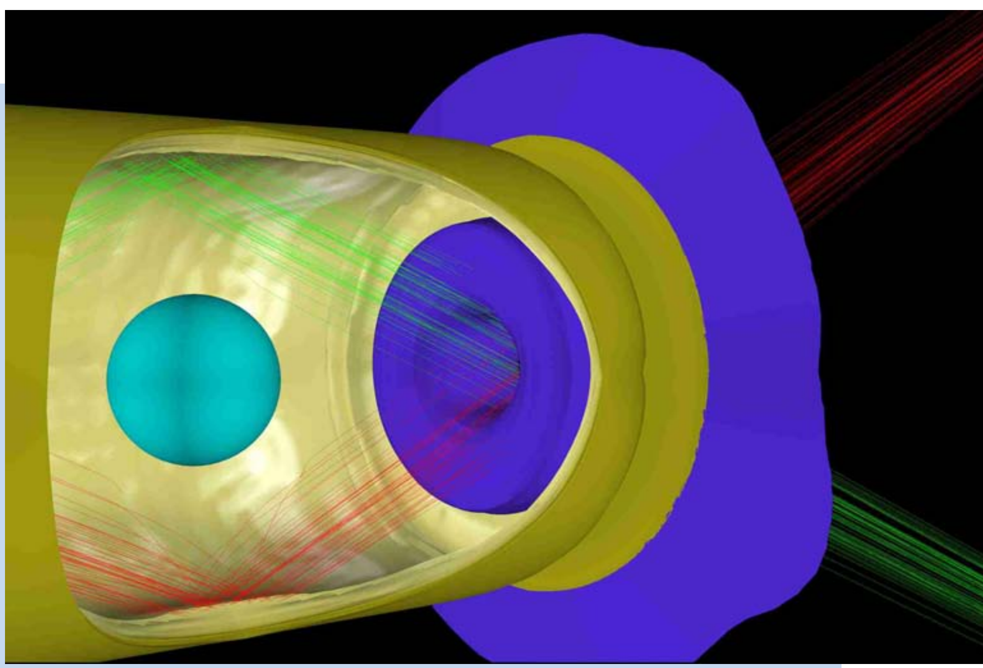


Figure 5. This figure shows 2 of the 192 Lawrence Livermore National Laboratory's National Ignition Facility laser beams heating the inner wall of a hohlraum (radiation container). The wall emits x-rays that implode the capsule at the center to densities and temperatures high enough that fusion occurs.

Integration with Directed Stockpile Work

Coordination between ASC and DSW is a significant aspect 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 weapons components and to define new, cost-effective, safe, and environmentally compliant manufacturing processes that will allow consistent nuclear weapons safety, security, and reliability in the future.

Integration with Defense Programs' (DP) Science Campaigns

The development of predictive capabilities relies on a strong experimental program to support the assessment of stockpile issues and to provide physics and materials 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 ASC 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. Working together with the Science Campaigns, ASC simulation tools are employed in the design of experiments. Data from these experimental programs provide ASC with the raw material necessary to evaluate and improve physics models to better characterize weapons performance and aging.

Integration with the Department of Energy (DOE) Office of Science and Other Government Agencies

Certain technical problems that arise in terascale computing are generic to scientific simulation and apply equally well to applications within the NNSA, DOE's Office of Science, and other government agencies such as the National Security Agency (NSA), Department of Defense (DoD), and Defense Advanced Research Projects Agency (DARPA). 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 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 ASC. Both programs are collaborating to identify areas of common interest and to establish appropriate coordination of efforts.

Risk Management

Risk management is a process for identifying and analyzing risks, executing 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 ASC's top ten risks, which are managed and tracked.

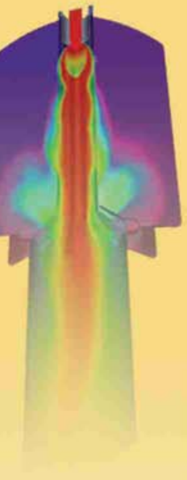
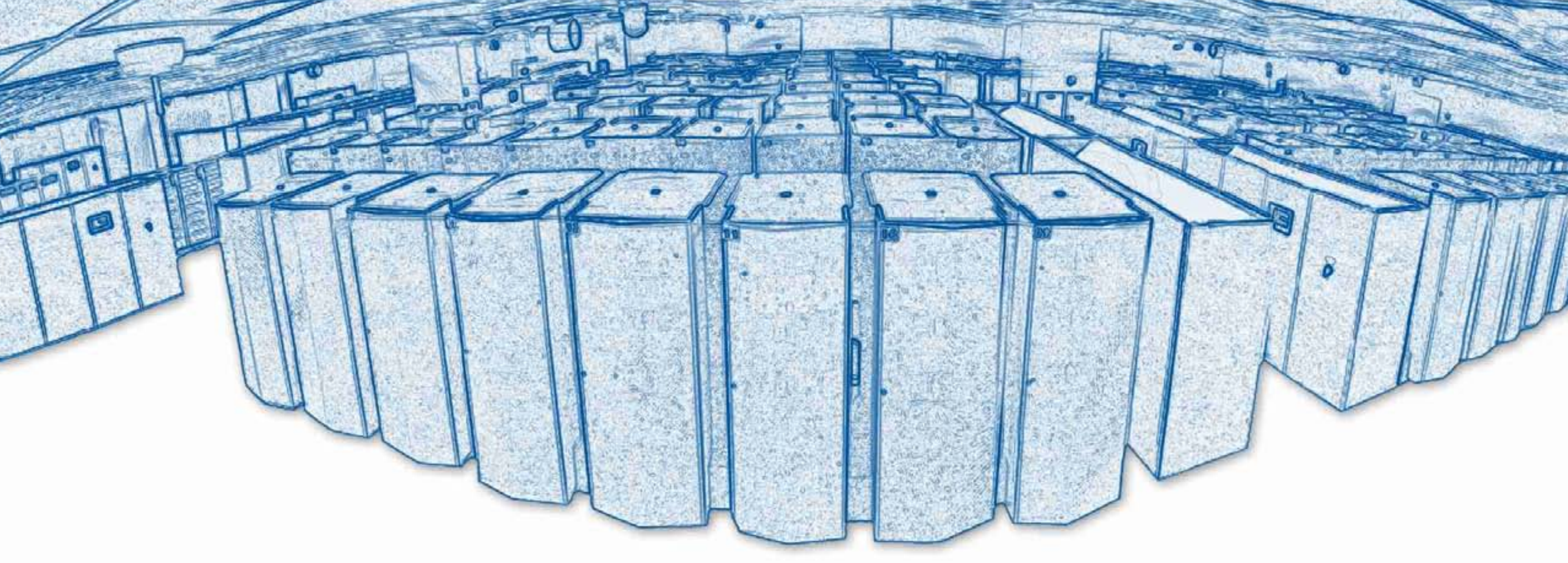


Table 2. ASC Top 10 Risks

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 that require-ments 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.
2	Designers, analysts, DSW, or other Campaign programs lack confidence in ASC 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 that capability and expertise are 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 that require-ments for computing are understood and appropriately set; maintain emphasis on system view of infrastructure and S&CS 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, ASC's mission, and the processes to set and align requirements and deliverables, consistent with applicable regulations.
9	Inadequate ASC computational environment impedes development and use of advanced applications on ASC platforms.	Moderate	Very Low	**LOW**	Integrate planning between program elements to anticipate application requirements and prioritize S&CS 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, ASC Centers, and academia and focus on test problem comparisons as part of software develop-ment process.



Appendices

Appendix A

ASC's Previous Level 1 Milestones

Previous ASC milestones (prior to FY 2004) 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 crashes and burns 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

Physics and Materials Modeling (Predecessor Materials & Physics 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

Data and Visualization Sciences (DVS) (Predecessor: 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

Appendix B

Performance Measures

Table B-1. ASC Performance Measures for FY 2004–2010

Goal: Provides leading edge, high-end simulation capabilities to meet weapons assessment and certification requirements, including weapon codes, weapon science, platforms, and computer facilities.

INDICATOR	ANNUAL TARGETS							ENDPOINT TARGET DATE
	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	
Peer-reviewed progress in completing milestones, according to a schedule in the Advanced Simulation and Computing Campaign Program Plan, in the development and implementation of improved models and methods into integrated weapon codes and deployment to their users. (Long-term Output.) Panel Criteria: (1) Delivery & implementation of validated models into code projects and (2) Documented verification of approximations.	High Fidelity Primary Code	Initial baseline Primary Code	Initial validated simulation code for W76 and W80	W80 code baseline	Conduct modern baseline of all enduring stockpile systems	Complete modern baseline of all enduring stockpile systems	Quantify margins & uncertain-ties of modern baseline simulations	By 2015, accomplish full transition from legacy design codes to modern ASC codes with documented quantification of margins and uncertainties of simulation solutions.
Cumulative percentage of the 31 weapon system components, primary/ secondary/engineering system, analyzed using ASC codes, as part of annual assessments & certifications. (Long-term Output.)	32%	38%	51%	67%	87%	96%	100%	By 2010, analyze 100% of 31 weapon system components using ASC codes, as part of annual assessments & certifications (interim target).
The maximum individual platform computing capability delivered, measured in trillions of operations per second (teraflops). (Long-term Output.)	40	100	100	200	200	350	350	BY 2009, deliver a maximum individual platform computing capability of 350 teraflops.
Total capacity of ASC production platforms attained, measured in teraOPS, taking into consideration procurements & retirements of systems. (Long-term Output.)	75	172	160	360	470	980	980	By 2009, attain a total production platform capacity of 980 teraflops.

Appendix C

ASC Risk Management Process

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.

ASC 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 that management may focus efforts on mitigating top risk items (Table C-1 and Table C-2). There are five different ASC risk types: Programmatic, Technical, Cost, Schedule, and Performance.

Risk Handling/Mitigation

Risk handling/mitigation is proactively undertaken to lessen consequence or likelihood and/or to develop contingency actions if risk issues develop (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 in DP status reports.

Table C-1 on the next page 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 because of 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 undercosting nor overcosting 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% undercosting or less than 5% overcosting 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% undercosting or greater than 5% overcosting 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% undercosting or greater than 10% overcosting 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% undercosting or greater than 10% overcosting 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 on the next page evaluates likelihood against programmatic or technical risks.

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

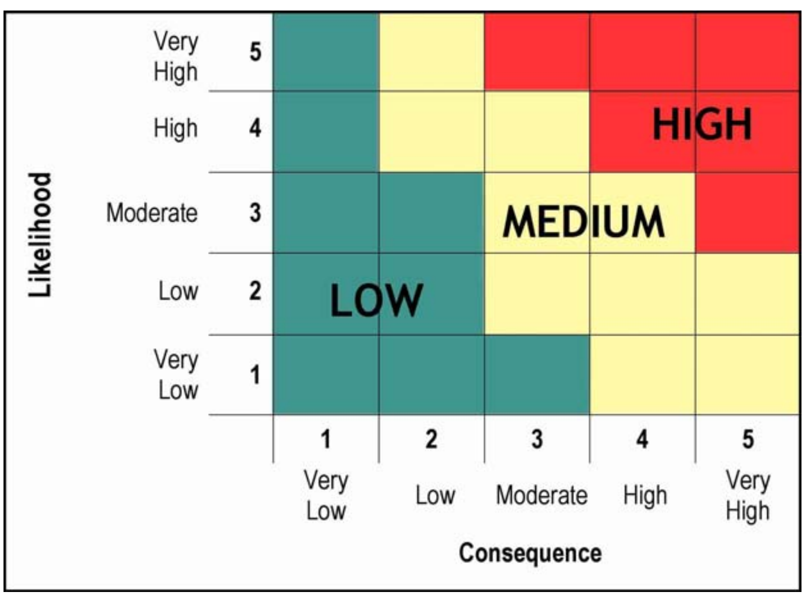
Table C-3 on the next page evaluates risk exposure, based on consequence and likelihood. Different risk-handling methods that relate to this exposure include:

- *Avoidance* – Uses an alternate approach, with no risks, if feasible. This approach can be applied to high and medium risks.
- *Control* – Develops a risk mitigation approach/action and tracks the progress of that risk. This approach is mostly applied to high and medium risks.
- *Assumption* – Accepts the risk and proceeds. This approach is usually applied to low-risk items.
  Risk Transfer – Passes the risk to another program element. This approach can be applied to external risks outside the control of the ASC Program.

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:** Nonchallenging 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. Risk Exposure Level Matrix



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

Appendix D

ASC Management Structure

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

Organization

ASC'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 ASC, 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 ASC program elements: Advanced Applications, Verification and Validation (V&V), Physics and Materials Modeling (P&M), Problem Solving Environment (PSE), DisCom, PathForward, Data and Visualization Science (DVS), 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 ASC Federal Program Manager and is communicated through the executive committee.
- *ASC's NNSA-HQ Team.* This team consists of NNSA federal employees and contractors, in concert with laboratory and plant representatives. The ASC HQ team is responsible for ensuring that ASC supports the SSP. The team facilitates ASC 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

ASC program management uses a planning process made up of elements described below. (Figure D-1 charts the planning and evaluation activities.)

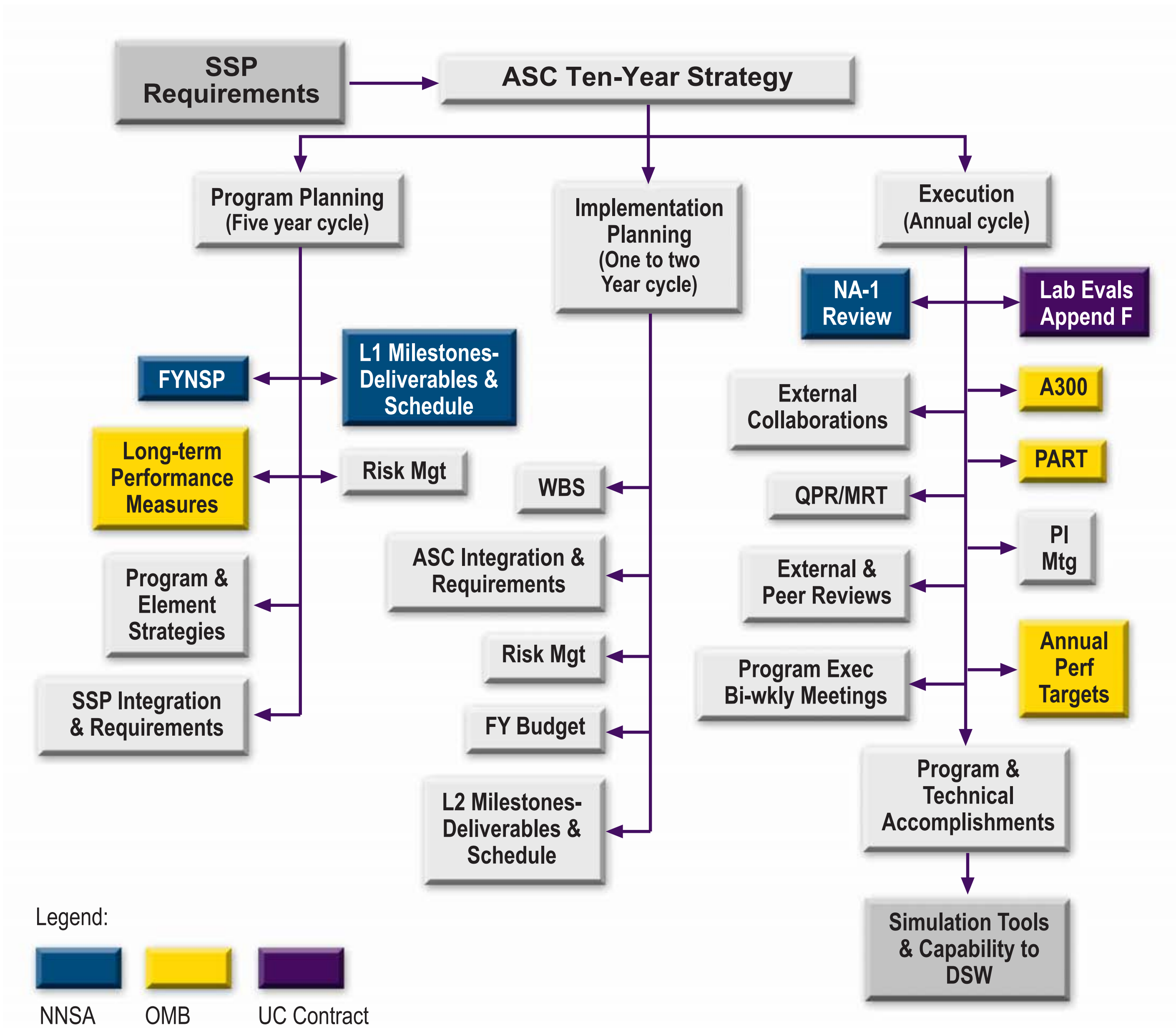
- *ASC Program Plan (PP) –* Provides the overall direction and policy for ASC. This functions as a strategic plan, and it identifies key issues and work areas for ASC in the next six years. This document is reviewed annually to ensure that ASC supports SSP needs.
- *ASC Implementation Plan (IP) –* This document is prepared annually and describes the work planned in two-year intervals at each laboratory to support the overall ASC objectives.
- *Program Milestones –* ASC milestones are a subset of NNSA National Level 1, Level 2, and other lower level laboratory-specific milestones. Level 1 milestones are milestones that are national priorities or that are high visibility at NA-10 or higher levels, usually require multisite and/or multiprogram coordination, and provide integration across ASC, DSW, and the Campaigns. Level 1 milestones may be specific to ASC or meet other SSP objectives with significant ASC support. Level 2 milestones are designed to execute the ASC strategy, demonstrate the completion of advanced ASC capabilities, and often support ASC Level 1 milestones, DSW deliverables, and/or major Campaign milestones. ASC set requirements for Certification of Completion that constitutes a body of evidence that certifies completion of Level 2 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 laboratory specific and are managed by the laboratories. Progress on Level 1 and Level 2 milestones is recorded in the NNSA Milestones Reporting Tool (MRT) and is reported quarterly to the Defense Program Director (NA-10) via the Quarterly Program Reviews (QPR) meetings and annually to the NNSA administrator (NA-1) via the annual technical review meetings.

- *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 ASC 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 the weapons laboratories in order to provide broader ASC peer review. The meetings also serve as an annual technical review for the DOE-HQ team.
  - *Executive Committee Meetings.* The ASC 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.* ASC program element teams conduct individual meetings to discuss progress, issues, and actions. The frequency of these meetings depends on the discretion of the ASC HQ program manager and his/her counterparts at the laboratories. These meetings identify issues that need to be elevated to the Executive Committee.
- *Reviews*
  - *External Reviews.* External reviews are conducted regularly by the laboratories to provide independent, critical insight to the laboratories on the technical progress of the ASC Program. The review panels consist of experts from academia, industry, and the national laboratories. Results of the reviews are provided to the laboratories and ASC HQ observers. These reviews augment other high-level reviews by laboratory, University of California, and Lockheed-Martin review committees.
  - *Internal Program Reviews.* Program reviews are organized at various levels to provide adequate assessment and evaluation of the ASC program elements. Each laboratory and each program element determine the scope and nature of the review as well as the form of reporting the results of such reviews that best suits their needs.
- *Performance Measurement*
  - This includes 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.

Figure D-1

ASC Program Planning and Evaluation Activities



Appendix E

Glossary

Advanced Applications
Element of DAM program area that provides physics and geometric fidelity for weapons simulations.

Advanced Architectures
An ASC 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.

ASC
Advanced Simulation and Computing Program. This program evolved from merging of the Accelerated Strategic Computing Initiative and the Stockpile Computing Program. The use of the acronym "ASCI" has been discontinued.

ASC Integration
One of ASC's five program areas.

ASC Purple
The next ASC system to be located at LLNL in 2005.

ASC Red Storm
A 40-teraOPS system, to be located at SNL, scheduled for delivery in FY 2004.

ASCI
Accelerated Strategic Computing Initiative

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 Red
An Intel system located at SNL. ASC 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 ASC Red to a 3.15 teraOPS platform.

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 budget and reporting classification codes.

Campaigns
An organization of SSP activities 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 ASC focused on computing at a distant location and data communications between geographically distant locations.

DoD
U.S. Department of Defense

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.

DVS
Data and Visualization Science, the ASC program element that provides the capability for scientists and engineers to "see and understand" the results of a simulation.

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.

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

I/O
Input/output

Institutes
A program element within the University Partnerships.

JASONs
A scientific advisory group providing consulting services to the U.S. Government on matters of science and technology.

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.

NPR
Nuclear Posture Review

M&PM
Material and Physics Modeling (M&PM); now P&M

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 Academies 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

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

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 ASC program element that partners with industry to accelerate the development of critical technology leading to commercial products needed by ASC.

Petabyte
10^{15} bytes; 1,024 terabytes

Petaflops
See PetaOPS

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 ASC 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 U.S. 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 SFIs, resolution comes from the Assessment & Certification element of DSW, often in partnership with ASC capabilities.

SLEP
Stockpile Life Extension Program. SLEP is the DP element responsible for planning and execution of component and weapons refurbishments.

SNL
Sandia National Laboratories, a prime contractor for NNSA with locations primarily in Albuquerque, New Mexico, and Livermore, California. 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 ASC 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.

teraflops
See teraOPS.

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 ASC'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 was the previous name for DVS, the ASC program element that provides the capability for scientists and engineers to "see and understand" the results of a simulation.

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.

NNSA
National Nuclear Security Administration

Sandia
National
Laboratories

Los Alamos
NATIONAL LABORATORY

Lawerence Livermore
National Laboratory