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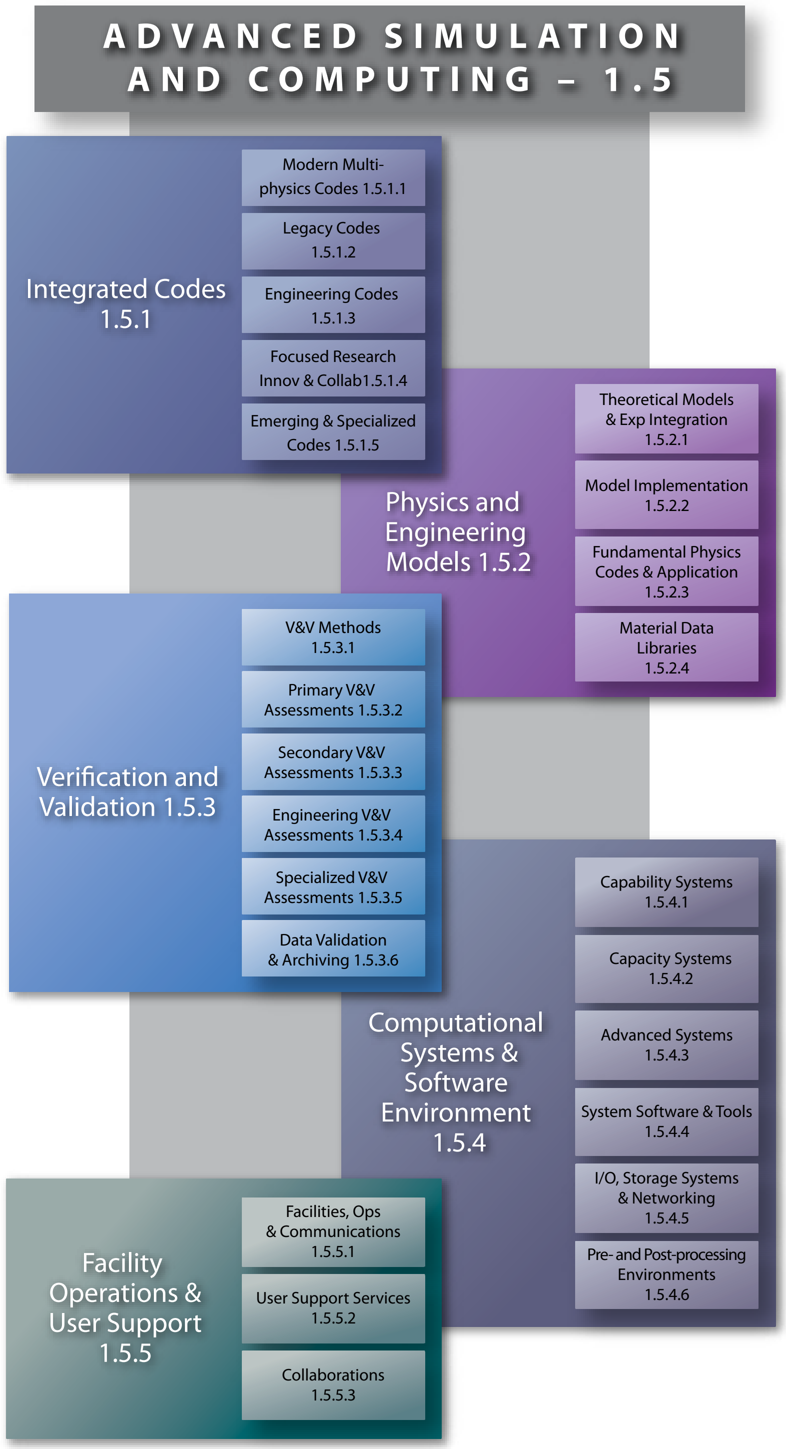
July 2005

ASC™

BUSINESS MODEL

National Nuclear Security Administration



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Advanced Simulation & Computing

Business Model

July 2005

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ASC Business Model

Introduction

The Advanced Simulation and Computing (ASC) Program is a national program that enables the Stockpile Stewardship mission. ASC creates simulation tools to be used in concert with expert scientific judgment to certify that the stockpile is safe, reliable, and secure. This is not only a massive scientific undertaking, but also a major management challenge to focus and apply resources effectively and efficiently while maintaining scientific creativity and nurturing innovation, which are keys to success.

ASC fulfills its mission by working closely with the other principal elements of National Nuclear Security Administration (NNSA) Defense Programs (DP), specifically, the Science and Engineering Campaigns and Directed Stockpile Work (DSW). The Campaigns develop certification methodologies that, in turn, drive requirements for ASC capabilities and products. The Campaigns also provide experimental data used to validate the models in the integrated codes that increase confidence in the results of simulations. DSW provides requirements for simulation, including planned Stockpile Lifetime Extension Programs (SLEPs), stockpile support activities that may be ongoing or require urgent, short-term response, and requirements for future capabilities to meet longer-term stockpile needs.

Accountability for performance is an important management principle for the ASC Program. This principle requires that technical excellence be coupled with effective business practices to deliver on requirements and that progress is periodically evaluated. The elements of the ASC management plan include a ten-year strategy, a business model reflected in a product-focused work breakdown structure, a program plan, and an annual implementation plan.

From ASCI's Past to ASC's Future

The management model for ASC has evolved since it began as the Accelerated Strategic Computing Initiative (ASCI) nearly ten years ago. As an initiative, it involved intense, sustained efforts at the three DP laboratories (Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories) as well as related unclassified scientific research and development conducted by researchers at several top universities. ASCI made enormous technical progress, as demonstrated in the unprecedented proof-of-principle weapons simulations carried out by complex software products (i.e., codes) embodying state-of-the-art numerical algorithms and physical models. These simulations were performed on a succession of increasingly powerful computing platforms, delivered through partnerships with U.S. high-end computing companies.

ASC must now transition its original business model, one that was very successful in delivering an initial capability, to one that is integrated and focused on requirements-driven products and response to fundamental technical questions that are necessary to move toward an enhanced predictive capability in simulation tools. The ASC *Business Model* acknowledges the need for sustained scientific and technical competence and sustained innovation to address future challenges.

As a program, ASC's main goal is to enable Stockpile Stewardship by:

- Improving the confidence in prediction through simulations;
- Integrating the ASC Program with certification methodologies;
- Developing the ability to quantify confidence bounds on the uncertainty of our results;
- Increasing predictive capability through the development of more accurate physics and engineering models and tighter integration of simulation and experimental activities;
- Providing the necessary computing capability to code users, in collaboration with industrial partners, academia, and government agencies.

ASC develops computer models that represent physical reality. The models are validated against integral nuclear test data obtained prior to the end of underground testing in 1992 as well as small-scale and integral nonnuclear experiments. The ASC Program merges modern simulation codes with appropriately powerful computing platforms and supporting infrastructure to enable weapons designers, analysts, and other users to perform accurate simulations quickly and efficiently. Providing the users with codes that correctly model the requisite physics, chemistry, and engineering continues to be the focus of management processes embodied in the *Business Model*.

A hierarchy of four major program documents provides guidance and direction for the ASC Program on how ASC goals will be achieved:

1. *The ASC Strategy: the Next Ten Years*,
2. *ASC Business Model*,
3. *ASC Program Plan*, and
4. *ASC Implementation Plan*.

The ASC Strategy: the Next Ten Years – This document articulates principles and high-level goals that guide the program's directions and emphases for the next ten years. It is the primary integrator that focuses the efforts of the ASC Program across the three DP laboratories toward an enhanced predictive capability.

Dr. Everet Beckner states the following in the Foreword to *The ASC Strategy: the Next Ten Years*:[1]

> The new strategic emphasis of the ASC Program illuminates several directions. It recognizes that many changes in the stockpile are inherently three-dimensional and the legacy codes cannot address issues in such geometries. It recognizes that most of the changes are small perturbations that must be resolved and their effects understood if we are to avoid the most conservative and expensive fixes. Congruent with these challenges, this strategy for the next ten years recognizes and addresses the need to replace the full-system experiments that were done with the best available models, material characterizations, and scientifically based representations. While the past nuclear test program allowed a particular balance between phenomenology (where our understanding was imperfect) and basic science (where we had the ability to apply it), the new policy of no full-scale nuclear experiments shifts the balance to one of minimum phenomenology and the best possible representations of physical behavior. We must do it in new ways that permit significant deviations from the design space.

1. NA-ASC-100R-04-Vol.1-Rev.0, August 2004

ASC Business Model – Advocacy, transparency, integration, and effective federal management are the touchstones of the new *Business Model*. It describes how NNSA Headquarters (HQ), in partnership with the three DP laboratories, will manage ASC as a national, integrated program. It is product-oriented, and clearly describes the products that comprise the program. The *Business Model* also identifies programmatic interfaces and customer-supplier relationships, woven together to make use of people, technology, and scientific resources in the service of nuclear national security. It describes the implementation of the program using program management best practices, processes, and tools.

ASC Program Plan – This plan describes the mission needs and out-year plan for the program. It documents linkages between the ASC and NNSA strategic objectives and the integration between the various NNSA elements. The *Program Plan* outlines the programmatic structure, the major deliverables, the resources required and the performance measures used to convey progress to external stakeholders.

ASC Implementation Plan – Each year an Implementation Plan (IP) is written that describes both the independent and integrated tasks of each of the DP laboratories. The IP outlines the technical activities committed to fulfill specific programmatic milestones for the current fiscal year, which are to be performed consistent with the goals outlined in *The ASC Strategy: the Next Ten Years* and the processes outlined in the *Business Model*. The IP outlines an annual action plan (identifying individual responsibilities) that builds incremental results, which, when rolled up, meet the overall program mission. The IP includes a budget table that identifies funding associated with Level-4 Products at each laboratory, based on Level-5 Projects.

Rationale for a New ASC Business Model

The work of ASC and the Stockpile Stewardship Program (SSP) is a major component of national security. The ASC mission requirement to extend the simulation tools into multiple dimensions and multiple length and time scales and to model material behavior in regimes of extreme temperatures and pressures makes this an enormously complex endeavor. ASC represents a considerable investment on the part of the nation, and doing this job well is critically important to national security. The *Business Model* is driven by principles that reflect these concerns:

- Ensure that the ASC Program meets its mission requirement.
- Develop a common understanding between NNSA HQ and the national laboratories on how to achieve milestones.
- Utilize the expertise and resources of the national laboratories in a more integrated manner.
- Support essential projects, some providing parallel or complementary capabilities, while removing unnecessary redundancy or duplication of effort. This will ensure that the program is truly a national program in which the laboratories are independent where that is critical, such as laboratory-specific primary and secondary codes, model development, and areas where a single point of failure is not acceptable.
- Ensure that requirements serve as drivers for the program and make clear that the high-priority tasks are appropriately addressed.
- Make readily apparent how the activities of the laboratories support the overall ASC Program.
- Increase the effectiveness of federal management and oversight of the program.
- Ensure that the long-term needs of the program are recognized and supported, as well as sustaining laboratory critical capabilities to be responsive to future needs.
- Preserve the scientific innovation and creativity necessary to achieve an enhanced predictive capability.

The *Business Model* was developed to ensure that achieving the ASC vision and mission are the foci of the ASC Program. The products of the national Work Breakdown Structure (nWBS) reflect the salient elements of the program mission — to develop the essential modern computational tools with input and support from theory and experiment. Effective management of the ASC Program is critical because of the impact of credible simulation on national priorities. Near-term commitments must be balanced with long-term research necessary to sustain progress. The *Business Model* ensures that our focus is on the high-priority areas.

Business Model Components

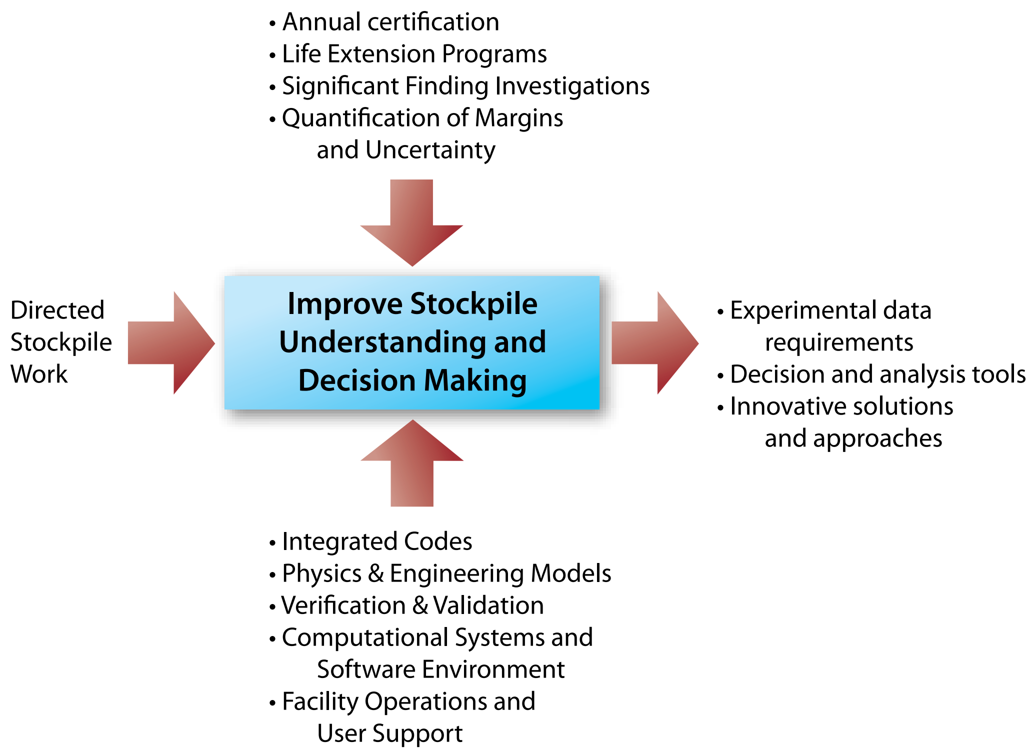
The ASC Program has five sub-programs, each of which has strong dependencies on the others: (1) Integrated Codes, (2) Physics and Engineering Models, (3) Verification and Validation, (4) Computational Systems and Software Environment, and (5) Facility Operations and User Support.

Implementation of the program in accordance with the *Business Model* emphasizes customer requirements and incorporates process flow diagrams, an nWBS, and a definition of the role of federal and laboratory program managers. The process flow diagrams (graphical representations of the tasks and interrelationships that make up each of the five sub-programs) are used to identify how requirements, both internal and external, drive program element tasks. The nWBS, a hierarchical division of all work within the ASC Program, facilitates prioritization of the tasks in the national program and development of an investment strategy, and it makes possible a resource-loaded schedule to chart the work to be performed each year.

Customer Requirements – It is essential to understand what products are needed by both the external customers such as Strategic Command (STRATCOM) representing the Services and internal customers such as the many users of ASC simulation tools for design and production activities.

ASC must be managed as an integrated enterprise that meets the needs of both sets of customers. It must be structured clearly so that it can be explained in a compelling way to the stakeholders. In the development of modern simulation tools, the outputs of one activity are vital to the success of another. For example, implementing new and improved theoretical models into the codes requires a smoothly functioning interface. A focus of the *Business Model* is to facilitate the management of internal and external interfaces. Internal interfaces include the interactions among ASC Program components and between the ASC Campaign, other Science Campaigns, and other elements of the SSP. External interfaces include interactions between NNSA and its customers and stakeholders.

As stated above, it is important to ensure that customer requirements are adequately identified, analyzed, and validated through the use of functional models. The diagram below illustrates this point, with major inputs (left) and outputs (right) depicted as well as requirements (top) and resources/mechanisms (bottom).



Process Flow Diagrams – The Process Flow Diagrams (PFDs) depict the interactions within the major elements of ASC. They use the language of the customer and supplier, and they clarify the inputs and outputs that lead to the final products of the major subprograms of the *Business Model*. The PFDs underpin the nWBSz. The arrows within a PFD may represent formal or informal relationships. PFDs change as processes are improved.

Appendix B contains PFDs for each of the subprograms.

National Work Breakdown Structure – ASC is a national program that transcends an individual DP laboratory. Currently, each laboratory develops its own work breakdown structure, which reflects site activities (and associated allocation of resources). Developing a work breakdown structure in support of an integrated national program is a shift in perspective and requires resource allocation that cuts across organizational boundaries.

The ASC nWBS consists of a hierarchy of tasks, from the project level up to the program level, and depicts the elements of all work necessary to deliver end products to the customer. Clearly defined activities, supported by the resources allocated through the nWBS, will contribute to the success of this endeavor. To make the *Business Model* a useful tool, explanations of the work being performed in the products and lower level projects of the nWBS will contain enough information that managers who are responsible for integration and who set priorities to support the national stockpile program can make informed decisions based on these details.

An integrated nWBS recognizes that at times some activities are performed by a single laboratory and at other times, shared or even duplicated. Such replication or redundancy enhances our ability to meet our mission needs, via risk mitigation and peer review. To preserve the peer review function, some capabilities must be independently developed at the laboratories. Yet others are more suitable to multi-laboratory collaboration that provides the ASC program with a standard tool or capability.

Integration can provide the greatest value for activities that are mission critical and that have issues (e.g., cross-organizational activities) that require particular attention. For these, the program would benefit greatly from increased formality to assist in managing product development and delivery. Federal program managers must have sufficient insight into products and projects to evaluate national program integration and to respond to congressional and Office of Management and Budget inquiries.

Appendix A includes the ASC nWBS and the associated product descriptions.

Implications to Management of the Program – The new *Business Model* will drive positive change throughout the program with its emphasis on a national program that is integrated across the laboratories, with activities prioritized to meet customer requirements. The tools described above that are being used to manage the national program more effectively will also be creatively used to increase communications across the laboratories and with sponsors to take a systems approach, prioritize work, and control costs. The PFDs, for example, will be used to facilitate the flow of information by developing regular channels for fruitful contacts and collaboration.

ASC has always emphasized the importance of incorporating into the codes the products of relevant basic research (models, algorithms, and data). To improve these efforts, ASC can use the specific arrows of the PFDs to implement more systematic communication and engagement among these groups. An example might be that one of the arrows in a flow diagram leads to the requirement that the modelers provide regular updates on model features available from both "physics labs" (Los Alamos and Lawrence Livermore), informing the code developers of new ideas and algorithms available for their projects. A venue to achieve this must apply across the DP laboratories, not just inside an individual laboratory.

Some channels for such communication among the laboratories already exist in the ASC Principal Investigator Meetings, Nuclear Explosive Code Developers Conferences (NECDC), Nuclear Weapons Engineering and Analysis Conference, specific technical interactions, and academic/professional society meetings and conferences. The interactions implied by a particular arrow in a PFD could lead to quarterly Physics and Engineering or V&V updates.

Role of the Federal and Laboratory Program Managers – The new ASC *Business Model* changes some of the roles of both the federal and laboratory program managers. The emphasis now is on an integrated ASC Program, and the changes in the role of each set of managers are intended to support and make the implementation of the *Business Model* successful.

The federal managers of the ASC Program will:

- Be advocates for the program;
- Ensure integration at HQ of ASC with DSW Science and Engineering Campaigns at Level 2;
- Set high-level goals and priorities for the national program;
- Allocate funding to the Level-3 Sub-programs and resource load the Level-4 Products;
- Understand the scope and enable the tri-lab integration of Level-4 Products;
- Monitor status of the Level-4 Products;
- Ensure appropriate interactions with other federal agencies;
- Coordinate program integration across laboratories;
- Provide technical input and oversight, as appropriate.

The laboratory managers at the three DP laboratories will:

- Collect requirements and feedback from ASC customers at Level 3 and translate into Level-4 deliverables that underpin the ASC plan covering the current Future Years Nuclear Security Program (FYNSP) period;
- Work with federal managers and other laboratory managers to integrate individual laboratory projects into national products;
- Maintain Level-3 Sub-program budgets according to HQ allocations;

- Finalize resource loading of Level-4 Products and work with federal managers, as needed, to achieve a balanced and integrated program at Level 4;

- Develop site work plans that directly map to the Level-5 Projects identified in the ASC Implementation Plan;

- Execute implementation plans according to scope, schedule, and budget;

- Interact with HQ and with other laboratories to improve collaboration and manage redundancy in the program.

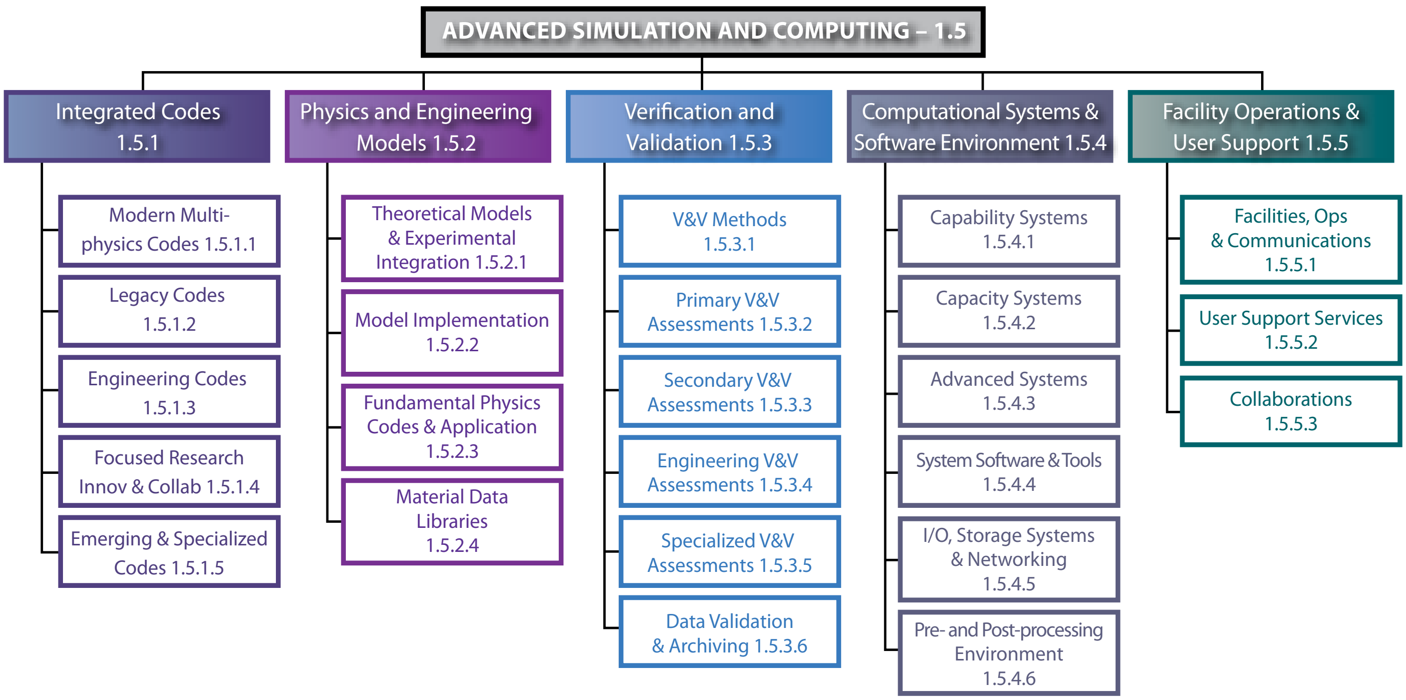
In summation, the responsibilities of the ASC federal managers are to prioritize the elements of the national program, to allocate resources at the sub-program level, and to monitor and evaluate the technical execution of the program. Federal managers will also ensure an integrated enterprise and advocate for it with the sponsors who appropriate the resources. The laboratory managers develop and execute technical projects that maintain weapons capabilities and deliver the products defined by stockpile needs, today and into the future.

Conclusion

Implementation of this *Business Model* requires a shift in the way that both the federal managers and the laboratory executives do their work. Decisions made at the individual laboratories will reflect and be consistent with the priorities of the national program. The *Business Model* will enable the federal managers to effectively manage an integrated national program, be more effective advocates for the component activities, and ensure that the resources allocated to the program are well managed and utilized.

Appendix A. ASC nWBS and Product Descriptions

The nWBS for the ASC Program begins at Level 2. Levels 2 through 4 are shown in the following diagram.



The ASC Program is at Level 2 within DP, and its sub-programs are at Level 3. They are (1) Integrated Codes, (2) Physics and Engineering Models, (3) Verification and Validation, (4) Computational Systems and Software Environment, and (5) Facility Operations and User Support. All provide key contributions in the effort toward attaining predictive capability. The products of the program are generated at Level 4 that are the result of laboratory projects at Level 5. This reflects a change in terminology used by the program in the past for Levels 4 and 5.

Within each Level-3 Sub-program, requirements drive and motivate delivery of Level-4 Products. For the Integrated Codes Sub-program, designers and analysts establish requirements that ensure their ability to meet commitments to external customers. Although there are important interfaces internal to this element, its primary purpose is to satisfy external drivers, directly or indirectly. For example, the annual assessment and certification process is a customer for the simulation tools, but that, in turn, responds to a statutory responsibility of the defense laboratories. The Physics and Engineering Models and Verification and Validation Sub-programs primarily support, and are necessary for the success of, the Integrated Codes Sub-program. Each Level-3 Sub-program has a PFD that graphically identifies essential activities, workflow processes, and interfaces with the other sub-programs. At this time, the Computational Systems and Software Environment and Facility Operations and User Support Sub-programs utilize the same PFD.

A.1—Integrated Codes 1.5.1

This sub-program constitutes laboratory code projects that develop and improve the weapons simulation tools, the physics, the engineering, and the specialized codes. These code projects are at varying levels of maturity, from recasted legacy codes that are able to run on advanced architectures to more sophisticated and accurate models and numerics being developed for representation in the next generation codes. This sub-program addresses the improvement of simulations of weapons systems that would predict, with reduced uncertainties, the behavior of devices in the stockpile, and which would begin the analysis and design for a Reliable Replacement Warhead. In general, the sub-program's products are large-scale, integrated simulation codes needed for (1) SSP maintenance, (2) the Life Extension Program, (3) addressing and closing Significant Findings, and (4) the support of dismantlement processes and future modifications. Specifically, products include legacy code maintenance; continued research into the applications and operations of engineering codes and manufacturing process codes; investigations and developments of future nonnuclear replacement components, algorithms, and computational methods as well as development of software architectures; advancement of key basic research initiatives; and explorations into emerging code technologies and methodologies. Also included in this sub-program are university grants and collaborations such as the ASC Alliances and Computational Science Graduate Fellowships which encourage laboratory-university collaboration. This sub-program's functional and performance requirements are established by designers, analysts, code developers, and the requirements of the Quantification of Margins and Uncertainties (QMU). Closely connected to this sub-program is the Physics and Engineering Models Sub-program because of its focus on the development of new models that would be implemented into the modern codes. Similarly, there is also the connection to the Verification and Validation program for assessing the degree of reliability and level of uncertainty associated with the outputs from the codes.

A set of specific activities that support the end products includes:

- Developing coupled multi-physics models for device simulation, based on fundamental understanding and realistic, scientifically based representation of device behavior, with a reduced reliance on calibration to underground test data.

- Developing integrated physics models with more accurate numerical methods for treating complex geometries in 2-D and 3-D computer codes.

- Developing capabilities to simulate effects of replacement components as well as to analyze various Stockpile-to-Target-Sequences (STSs) and modifications to ensure nuclear surety.

- Accelerating code performance through more powerful numerical algorithms and improved approximations.

- Enhancing interactions with academic colleagues in computer science, computational mathematics, and engineering.

- Investigating basic research results relevant to the ASC Program in computer science, scientific computing, and computational mathematics at the laboratories.

- Providing continued support to the Computational Science Graduate Fellowship programs, funded jointly by the DOE Office of Science, designed to engage doctoral candidates in basic and applied science or engineering disciplines with applications in high-performance computing.

Modern Multi-physics Codes 1.5.1.1

This is a suite of large-scale, integrated multi-physics simulation codes and major physics packages needed for the SSP, including the classified codes used by designers and analysts to simulate the nuclear safety, performance, and reliability of stockpile systems. The products are complex, integrated hydro, radiation-hydro, and transport codes for application to Stockpile Stewardship; design and analysis of experiments; general purpose hydro and radiation-hydro problems; and analysis of radiation and particle transport problems for a variety of applications. In addition, codes from this suite will be utilized to simulate other dynamic events, including high-explosive, laser, and pulsed-power driven systems; sub-critical and above-ground experiments; inertial confinement fusion (ICF); and the response of energetic materials to thermal and mechanical insults. The codes are designed to run in parallel and make effective use of advanced ASC computing platforms.

Performance Targets: Release improved versions of modern multi-physics codes and support the users who apply these codes to stockpile issues, implement models to meet user requirements, and enhance the codes for increased predictive capability.

Legacy Codes 1.5.1.2

This product is the maintenance of, and the requisite limited enhancements of, the suite of legacy and related support codes historically used for the design of primaries and secondaries, and for engineering analyses. Legacy codes serve as established tools for nuclear weapons simulation, with well-understood capabilities and limitations for Stockpile Stewardship applications. They serve as reference points for the assessment of new codes, models, and algorithms. For designers, they represent a link to the era of active nuclear weapon design and testing and thus provide well-calibrated reference simulations and serve as standards for evaluating the effectiveness of new simulation tools.

Performance Targets: Maintain ability to run selected legacy codes using legacy input files to serve as a reference for modern multi-physics and engineering codes.

Engineering Codes 1.5.1.3

This product is a suite of engineering and manufacturing applications codes and supporting frameworks used for Stockpile Stewardship activities (such as annual certification), life extension programs, and significant finding investigations. Engineering applications codes support analyses such as thermal, structural, and electrical/electromagnetic modeling of weapon components and systems under normal, abnormal, and hostile environments. Manufacturing process codes support casting, welding, forging, and encapsulation operations.

Engineering applications codes are also being developed within frameworks to support complex coupled multi-physics (e.g., thermo-mechanical, thermo-chemical or electro-thermo mechanical capabilities). Code support and feature enhancement are focused to meet user needs across the tri-lab engineering community.

Performance Targets: Release improved versions of engineering codes and support the users who apply these codes to stockpile issues, implement models to meet user requirements, and enhance the codes for increased predictive capability and applications breadth.

Focused Research, Innovation, and Collaboration 1.5.1.4

This product is focused on research, innovation, and collaboration with other ASC sub-programs, laboratories, and the greater scientific community to investigate and develop future technologies, algorithms, and computational methods. This research enables advances toward greater predictive capability by focusing on overcoming critical obstacles in integrated codes (e.g., the need for robust efficient solvers, design and optimization algorithms, and innovations that improve code effectiveness). Exploratory efforts include short-term focused research projects, as well as longer-term, more innovative efforts aimed at the large challenges. Activities also include application-specific computational science research, such as development of software architectures that enable application of new and coupled physics, models, and verified algorithms to problems of interest. Research is conducted at the laboratories and through collaborations with academic researchers.

Performance Targets: Research, develop, and maintain algorithmic capabilities for codes and integrate advances of the external scientific community into code activities.

Emerging & Specialized Codes 1.5.1.5

This product explores promising, emerging technologies that are not yet mature enough for use in the modern multi-physics codes, specialty codes that simulate relevant complex processes in unique environments, and supporting codes that are closely tied to user applications for problem setup and analysis. This suite of codes will change as new methods are explored and new application-specific requirements are identified. Specialty codes have detailed physics focused on unique applications (e.g., ICF laser-plasma interactions or direct numerical simulation of turbulence). The supporting codes are application-specific problem setup and physics-based post-processing codes.

Performance Targets: Deliver capabilities and prototype applications for classes of experiments or phenomena requiring specialized physics and engineering models. Implement promising approaches in special-purpose codes for development and evaluation for broader use in integrated codes.

A.2—Physics and Engineering Models 1.5.2

This sub-program develops microscopic and macroscopic models of physics and material properties, as well as improved numerical approximations to the simulation of transport for particles and x-rays and other critical phenomena. This sub-program is responsible for the development, the initial validation, and the incorporation of new models into the Integrated Codes; therefore, it is essential that both sub-programs be interdependent. There is also extensive integration with the SSP experimental programs, mostly funded and managed by the Science Campaigns such as Dynamic Materials Properties, and the Engineering Campaign. Functional requirements for this sub-program are established by designers and analysts.

A set of specific activities that support the end products includes:

- Developing equation-of-state (EOS) and constitutive models for materials within nuclear devices, improved understanding of phase diagrams and the dynamic response of materials.
- Developing physics-based models representing the altered properties of plutonium as it ages, partly as a result of self-irradiation.
- Developing fundamental chemistry 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.
- Improving representation of corrosion, polymer degradation, and thermal-mechanical fatigue of weapons electronics.
- Developing more representative models of melting and decomposition of foams and polymers in safety-critical components.
- Building better models of microelectronic and photonic materials under hostile environments in support of the STS requirements.

Theoretical Models & Experimental Integration 1.5.2.1

This product is responsible for developing science-based models of physical processes, materials response, and properties with the goal of improving predictive capabilities. This includes mechanical, chemical, nuclear, and other physical processes. Near term, this also includes the development of science-informed phenomenological models to address physical phenomena that are not fully understood. This product also supports the development of theoretical descriptions of physical properties required for specialized physics codes, for example, the development of interatomic potentials for molecular dynamics simulations. Experimental data are required to guide the development of the models, and this product is responsible for setting requirements for measurements (definition of properties to be studied, the regimes of interest, and accuracy required), helping in the interpretation of these data, and using these data to validate and advance theory and models. This involves extensive collaborations with the scientific community, both internal (Campaigns, Laboratory-Directed Research & Development, Work for Others, etc.) and external to the laboratories.

Performance Targets: Validated new theory and models subsequently are implemented into the ASC simulation codes, and are also used to generate improved material data libraries for the codes.

Model Implementation 1.5.2.2

This product develops numerical realizations for implementation into multi-physics and engineering codes. This includes the development of various algorithms for solving equations. A key challenge of this element is the implementation of the new models into ASC codes. This product also addresses the issue of modularization and portability of models for the codes and requires strong integration with the ASC Integrated Code Sub-program. Small-scale laboratory experimental data are required to generate model parameters. Verification and validation suites that include comparisons with experimental data and documentation will accompany the delivery of the models into the codes.

Performance Targets: Advances have been made when the ASC codes incorporate higher-fidelity models for representing physical phenomena.

Fundamental Physics Codes and Application 1.5.2.3

This product is distinct from large-scale ASC codes. These codes are used to investigate specific physical phenomena and generate fundamental physical data. For example, molecular dynamics simulations are used in particular applications to develop insight into physical phenomena as well as to compute specific material properties. Special-purpose codes are also used to develop and evaluate models prior to insertion into the integrated codes. In certain cases, these tools may also be used directly to answer specific questions from customers. This involves extensive collaborations with other campaigns and other internal scientific activities. These physics codes are unique resources of the laboratories and integrate many years of advances in scientific research and development.

Performance Targets: These codes are used to populate improved material databases used by the ASC codes and to advance understanding of fundamental physical processes.

Material Data Libraries 1.5.2.4

This product provides numerically generated representations of material properties and physical data including equation-of-state (EOS), opacities, cross-sections, engineering material properties, etc. It also provides numerically accessible libraries of these data utilized by material models in integrated codes. Experimental data are required both to develop and perform preliminary validation of these libraries. But since many regions represented in the databases are inaccessible to measurement, the databases also rely largely on theory and the specialized physics codes mentioned above. In addition to the libraries, there are supporting processing codes that make these data available to the ASC simulation codes.

Performance Targets: Releases of improved material data libraries (EOS, nuclear data, opacities, etc.). Demonstrated improvement in ASC simulations utilizing these libraries.

A.3—Verification and Validation 1.5.3

Based on the functional and operational requirements established by designers, analysts and code developers for greater fidelity of codes and models, this sub-program establishes a technically rigorous foundation for the credibility of code results. This sub-program interfaces with the Integrated Codes Sub-program to obtain regular, official code releases from the code projects. Verification activities assess code precision in implementing numerical approximations and assess the accuracy of these numerical approximations. Validation activities aid in the understanding and assessment of a model's accuracy by comparing model predictions with experimental data. Quantification methodologies provide measures of the uncertainties associated with the simulations. Sound software quality engineering practices are used to ensure robust, efficient, and well-documented software releases of the ASC codes. This sub-program collaborates with the Science and Engineering Campaigns and DSW to obtain experimental data for validation purposes. Final V&V assessment reports contain the standard deliverables of this sub-program.

A set of specific activities that support the end products includes:

- Defining and documenting methodologies for quantification of results, providing the basis by which computational uncertainties are assessed and evaluated.
- Increasing efforts to develop common verification and validation test suites, cutting across organizations and even external to a given laboratory to examine the adequacy and correctness of the ASC models and codes.
- Identifying requirements and performing comparison calculations against experimental validation data obtained through the experimental Science Campaigns.
- Developing and maintaining repositories of V&V outputs, including data, test results, and analyses, to be accessible to the Stockpile community.
- Developing software quality standards stemming from customer or regulatory requirements and improved software engineering tools and practices for application to ASC simulations.

V&V Methods 1.5.3.1

This product provides methods, measures, and standards necessary to assess the credibility of the ASC codes and models, quantify confidence in ASC calculation results, and measure the progress in the ASC predictive capabilities. This product will be the entry point for advanced technologies in support of establishing credibility in code predictions. In this role, V&V will be aware of leading research, perform its own research, and be an advocate for advanced research and methods development in the areas of code verification, solution verification, validation metrics and methodology, and Uncertainty Quantification (UQ) as an enabling technology for validation and risk-informed decisions. Standards are designed to establish high-quality expectations for ASC codes to ensure their robustness, portability, and longevity. These standards include establishing high-level software quality requirements, assessment techniques and methods, and development of Software Quality Engineering (SQE) tools.

Another aspect of the Methods product includes development of suites of application-relevant code verification problems and support of the development of advanced techniques of code and solution verification. This element will host the development of validation metrics as a formalized quantitative means for comparing calculations and experimental data and inferring levels of confidence in the calculation. It will develop methods for quantifying the impact of variabilities and uncertainties in the decision context (QMU) and develop methods for measuring the sensitivity of decision metrics to uncertainties in modeling inputs. This requires extensive collaboration with other ASC program elements, alliances, academia, and other SSP campaigns.

Performance Targets: Research, develop, improve, and maintain V&V standards, metrics, and test problems to measure credibility and predictive capabilities of ASC simulations.

Primary V&V Assessments 1.5.3.2

This product delivers science-based assessments of the predictive capability and uncertainties in the performance code's primary physics and related models to support the needs of the SSP. This product evaluates the models and numerical algorithms pertaining to primary applications. This product focuses on establishing credibility in primary simulation capabilities by collecting evidence that the numerical models are being solved correctly and that the primary simulation model is being solved correctly. It examines (1) whether the computational models are the correct implementation of the conceptual models for hydrodynamics, EOS, high explosive, and strength of material and (2) whether the resulting code can be properly used for an analysis. Also, it examines whether the conceptual models, computational models as implemented into the primary codes, and computational simulation agree with real-world observations. The scope of this product includes planning and experiment design, Software Quality Assurance (SQA), verification assessments, UQ, validation assessments (integral and hierarchical), predictive accuracy, estimation, and documentation for the primary. This requires extensive collaboration with the various ASC elements, DSW, and Campaigns.

Performance Target: Provide measures of progress and confidence in primary codes toward predictive capabilities.

Secondary V&V Assessments 1.5.3.3

This product delivers science-based assessments of predictive capability and uncertainties in secondary performance codes and related models to support the needs of SSP. This product includes the evaluation of secondary simulations within its functional and operational requirements. Innovative mathematical techniques and analysis tools (developed by the V&V Methods above) are utilized to produce assessments at the system, sub-system, and component levels, and they measure progress in reducing phenomenology in the weapon simulation codes. The results of such simulations are compared to the experimental diagnostic measurements in order to understand the operation and performance of nuclear weapons, and thus, they help to maintain and develop capability, as well as to assure the safety and integrity of the current stockpile. A thorough understanding of the physics involved in the actual diagnostic techniques is also crucial to the interpretation of the experimental data. The interpretation of UGT data requires a deep understanding of many branches of physics, including high- and low-temperature plasma physics, hydrodynamics, nuclear reactions, thermonuclear reactions, and the transport of energy by radiation and conduction. The scope of this product includes planning and experiment design, SQA, verification assessments, UQ, validation assessments (integral and hierarchical), predictive accuracy estimation, and documentation for the secondary. Extensive collaboration is required with the various ASC elements, DSW, and Campaigns.

PERFORMANCE TARGET: Provide measures of progress and confidence in secondary codes toward predictive capabilities.

Engineering V&V Assessments 1.5.3.4

This product focuses on systematic assessments of predictive capability and uncertainties in engineering codes and related models to support the needs of SSP. This product focuses on measuring the level of confidence in these code results that are used to investigate specific physical phenomena and generate fundamental physical data. The scope of this product includes planning and experiment design, assessments of software quality, verification assessments, validation assessments (integral and hierarchical), UQ, predictive accuracy estimation, and documentation. This involves extensive collaborations with other SSP campaigns and other scientific activities. Validation assessments span a full hierarchy from unit and separate effects level validation, benchmark and mock-up level validation, and war reserve and full-system level validation. V&V will play a lead role in ensuring common verification practices and work products across all activities. V&V must collaborate with DSW, the Science and Engineering Campaigns, and Physics and Engineering Models to develop an integrated system of activities that support resolution of a particular DSW issue.

PERFORMANCE TARGET: Provide measures of progress and confidence in engineering codes toward predictive capabilities.

Specialized V&V Assessments 1.5.3.5

This product focuses on systematic assessments of predictive capability and uncertainties in specialized and safety codes and related models to support the needs of SSP. This product focuses on measuring the level of confidence in the codes results that are used to investigate specific physical phenomena and generate fundamental physical data. The scope of this product includes planning and experiment design, SQA, verification assessments, UQ, validation assessments (integral and hierarchical), predictive accuracy estimation, and documentation. This involves extensive collaborations with other SSP campaigns and other scientific activities, as well as extensive collaboration with the Integrated Codes, Physics & Engineering Models, Facility Operations and User Support, and Campaigns.

PERFORMANCE TARGET: Provide measures of progress and confidence of ASC specialized codes toward predictive capabilities.

Data Validation and Archiving 1.5.3.6

This product provides traceable and reproducible work products and processes for certification (short and long term). The scope of this product includes integral validation of nuclear data that provide input physical data for various weapon relevant materials; additionally, this product includes work product and data archiving and simulation pedigree tracking. This requires extensive collaboration with the other sub-programs as well as with the other Campaigns.

PERFORMANCE TARGET: Ability to access data needed to perform integral validation studies, assessments of nuclear data fidelity, and ability to capture and archive simulation input pedigree.

A.4—Computational Systems and Software Environment 1.5.4

This sub-program provides ASC users a stable, seamless computing environment for all ASC deployed platforms, including capability, capacity, and advanced systems. It is responsible for delivering and deploying the ASC computational systems and user environments via technology development and integration at the DP laboratories, in addition to partnerships with industry and academia. The scope of the sub-program includes strategic planning, research, development, procurement, maintenance, testing, integration and deployment, and quality and reliability activities for all ASC computational systems and software environments. Functional and operational computational requirements for this sub-program are established by the weapons designers, analysts, and code developers. This sub-program identifies computer science and system development opportunities in emerging technologies based on market surveys, vendor discussions, and interagency and academic collaborations.

A set of specific activities that support the end products includes:

- 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.

- Producing an end-to-end, high-performance Input/Output (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.
- Providing a reliable, available, and secure environment for distance computing, through system monitoring and analysis, modeling and simulation, and technology infusion.
- 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.
- Deploying and providing system management of the ASC computers and their necessary networks and archival storage systems.
- Stimulating research and development efforts through advanced architectures that explore alternative computer designs, promising dramatic improvements in performance, scalability, reliability, packaging, and cost.

Capability Systems 1.5.4.1

This product provides capability production platforms and integrated planning for the overall system architecture commensurate with projected user workloads. The scope of this product includes strategic planning, research, development, procurement, hardware maintenance, testing, integration and deployment, and quality and reliability activities, as well as industrial and academic collaborations. Projects and technologies include strategic planning, performance modeling, benchmarking, and procurement and integration coordination. This product also provides market research for future systems.

Capacity Systems 1.5.4.2

This product provides capacity production platforms commensurate with projected user workloads. The scope of this product includes planning, research, development, procurement, hardware maintenance, testing, integration and deployment, and quality and reliability activities, as well as industrial and academic collaborations. Projects and technologies include the procurement and installation of capacity platforms.

Advanced Systems 1.5.4.3

This product provides advanced architectures and problem-optimized systems in response to program need. The scope of this product includes strategic planning, research, development, procurement, testing, integration and deployment, and industrial and academic collaborations. Projects and technologies include strategic planning, performance modeling, benchmarking, and procurement and integration coordination. This product also provides market research, and the investigation of advanced architectural concepts and hardware (including node interconnects and machine area networks) via prototype development, deployment, and test bed activities. Also included in this product are cost-effective computers designed to achieve extreme speeds in addressing specific, stockpile-relevant issues through development of enhanced performance codes especially suited to run on the systems.

System Software and Tools 1.5.4.4

This product provides the system software infrastructure, including the supporting operating system environments and the integrated tools to enable the development, optimization, and efficient execution of application codes. The scope of this product includes planning, research, development, integration and initial deployment, continuing product support, and quality and reliability activities, as well as industrial and academic collaborations. Projects and technologies include system-level software addressing optimal delivery of system resources to end users, such as schedulers, custom device drivers, resource allocation, optimized kernels, system management tools, compilers, debuggers, performance tuning tools, run-time libraries, math libraries, component frameworks, other emerging programming paradigms of importance to scientific code development, and application performance analysis.

Input/Output, Storage Systems and Networking 1.5.4.5

This product provides I/O (or data transfer), networking technologies, and storage infrastructure in balance with all platforms and consistent with integrated system architecture plans. The procurement of all supporting subsystems, and data transfer and storage systems and infrastructures, occurs through this product. The scope of this product includes planning, research, development, procurement, hardware maintenance, integration and deployment, continuing product support, and quality and reliability activities, as well as industrial and academic collaborations. Projects and technologies include high-performance parallel file systems, hierarchical storage management (HSM) systems, storage-area-networks (SANs), network-attached-storage (NAS), and High Performance Storage System (HPSS) or future HSM system disks, tape, robotics, servers, and media. This product also includes relevant prototype deployment and test-bed activities. Projects and technologies in the advanced networking and interconnect areas will include networking and interconnect architectures, emerging networking hardware technologies and communication protocols, network performance/security monitoring/analysis tools, and high-performance encryption and security technologies.

Pre- and Post-Processing Environments 1.5.4.6

This product provides integrated environments to support end-user simulation setup and post-processing visualization, data analysis, and data management. The scope of this product includes planning, research, procurement, development, integration and deployment, continuing customer/product support, and quality and reliability activities, as well as industrial and academic collaborations. Projects and technologies include tools for optimized problem set-up and meshing, metadata and scientific data management, and application-specific and general-purpose visualization, analysis, and comparison. Research includes innovative data access methods and visualization of massive, complex data. Special focus will be placed on tools for improving end-user productivity. Also included are procurement, deployment, and support of data manipulation and rendering visualization servers, office and collaborative space visualization displays, mechanisms for image data delivery, and custom graphics rendering hardware.

A.5—Facility Operations and User Support 1.5.5

This sub-program provides both necessary physical facility and operational support for reliable production computing and storage environments as well as a suite of user services for effective use of ASC tri-lab computing resources. The scope of the facility operations includes planning, integration and deployment, continuing product support, software license and maintenance fees, procurement of operational equipment and media, quality and reliability activities, and collaborations. Facility Operations also covers physical space, power and other utility infrastructure, and LAN/WAN networking for local and remote access, as well as requisite system administration, cyber-security, and operations services for ongoing support and addressing system problems. Industrial and academic collaborations are an important part of this sub-program.

The scope of the User Support function includes planning, development, integration and deployment, continuing product support, and quality and reliability activities collaborations. Projects and technologies include computer center hotline and help-desk services, account management, Web-based system documentation, system status information tools, user training, trouble-ticketing systems, and application analyst support.

The designers, analysts, and code developers of the Nuclear Weapons Complex provide functional and operational computational requirements.

A set of specific activities that support the end products includes:

- Providing continuous and reliable operation and support of production computing systems and all required infrastructure to support these systems on a 24 hours a day, 7 days a week basis. The emphasis is on providing efficient production quality support of stable systems.

- Ensuring that the physical plant has sufficient resources (such as space, power, cooling) to support future computing systems.

- Providing the authentication and authorization services used by applications for remote access and data movement across ASC sites.

- 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).

- Enabling remote access to ASC applications, data, and computing resources to support computational needs at the Plants.

- 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.

Facilities, Operations, and Communications 1.5.5.1

This product provides necessary physical facility and operational support for reliable production computing and storage environments. The scope of this product includes planning, integration and deployment, continuing product support, software license and maintenance fees, procurement of operational equipment and media, quality and reliability activities, and collaborations. This product also covers physical space, power and other utility infrastructure, and Local Area Network/Wide Area Network networking for local and remote access, as well as requisite system administration, cyber-security, and operations services for ongoing support and addressing system problems.

User Support Services 1.5.5.2

This product provides users with a suite of services enabling effective use of ASC tri-lab computing resources. The scope of this product includes planning, development, integration and deployment, continuing product support, and quality and reliability activities collaborations. Projects and technologies include computer center hotline and help-desk services, account management, web-based system documentation, system status information tools, user training, trouble-ticketing systems, and application analyst support.

Collaborations 1.5.5.3

This product provides collaboration with external agencies on specific high-performance computing projects. The scope of this product includes planning, development, integration and deployment, continuing product support, and quality and reliability activities collaborations. This product also includes any programmatic support across the entire ASC Program and studies, either by internal or external groups, that enable the program to improve its planning and execution of its mission.

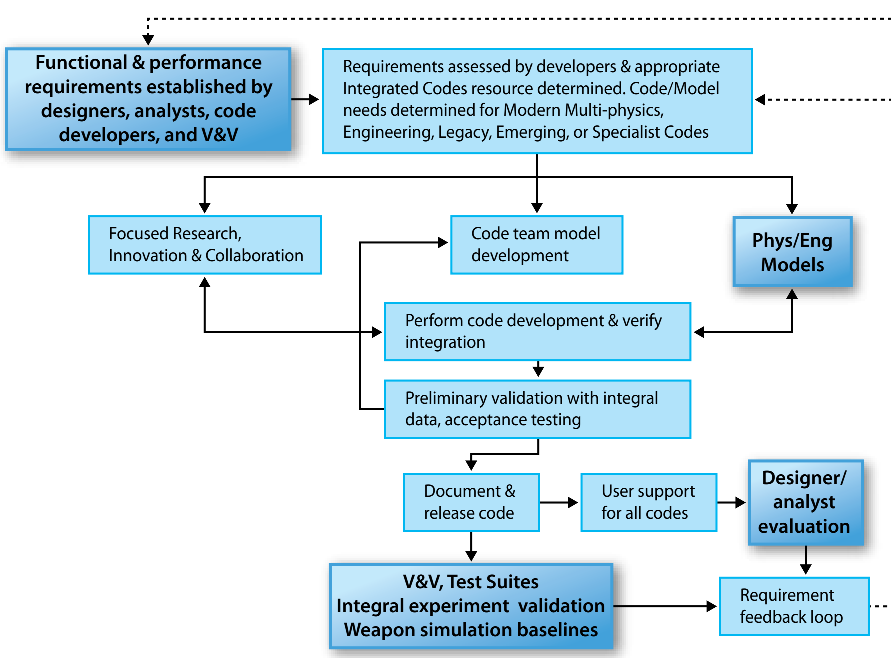
Appendix B. ASC Process Flow Diagrams

Process Flow Diagrams (PFDs) illustrate the requirements and the products and show how they drive the development process. The major contributing components are shown with arrows in the direction of information and product flow. The arrows in the PFDs indicate in a notional way the flow of information between activities. In some instances, they represent requirements from one activity to another; in others, they are customer/supplier communications. These PFDs should be understood as generalizations for all three laboratories and not necessarily as formally documented hand-offs. They are intended to be dynamic so that, as work flows are improved or fine-tuned, they can be further fleshed out and changed through discussions and agreements among the sites and HQ.

B.1—Integrated Codes Process Flow Diagram

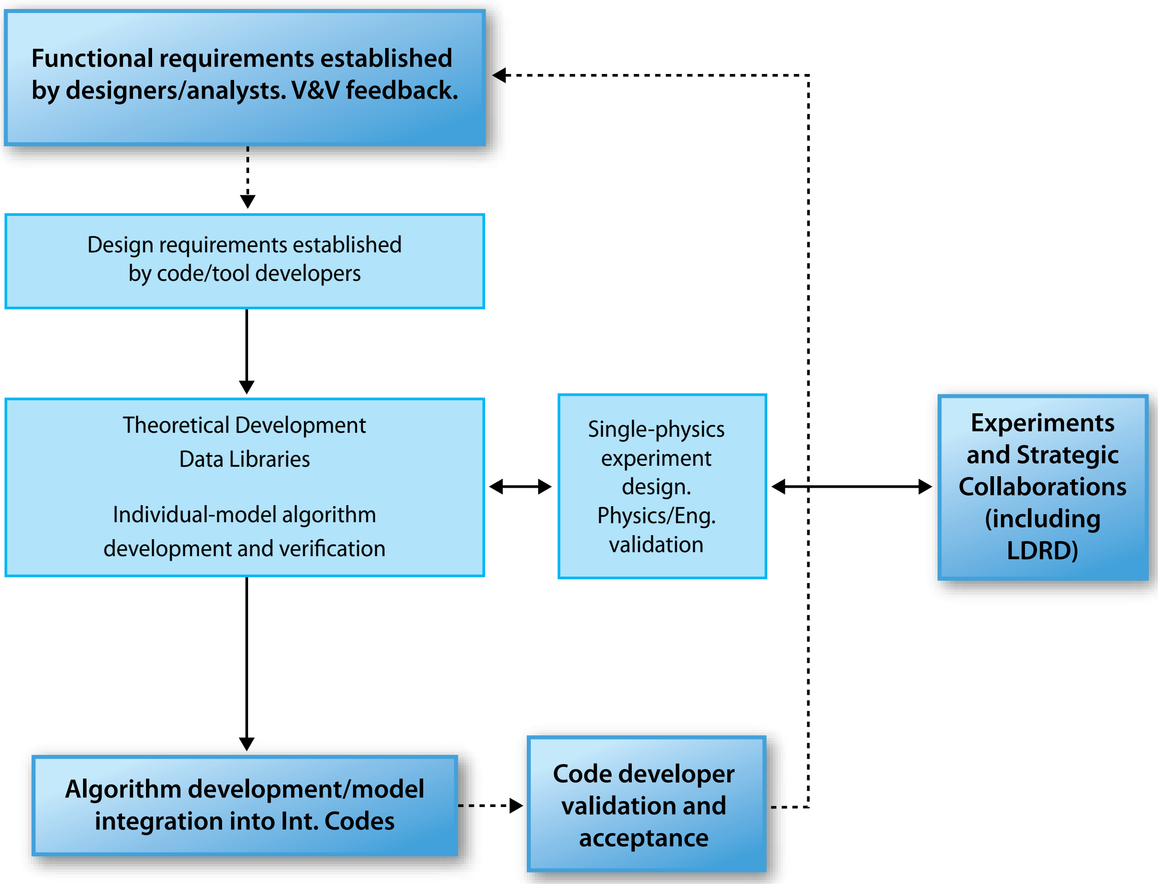
An example of the process flow would be how a requirement flows from the code developers to the modelers for improved physics representation of some feature of device behavior. The modelers, in turn, request experimental data to test their hypotheses from one or another Science Campaign and then return the model to the code developers, perhaps even participating in its incorporation into the modern code. Initial V&V with integral data is performed by the code development team.

At a high level, the Physics and Engineering Models Sub-program receives requirements from those responsible for stockpile deliverables and develops application tools to meet those requirements. The application tools are steadily improved through the implementation of better models and algorithms from this sub-program. The models are validated through feedback loops between the model developers and the data providers in the Science Campaigns. Model implementation is verified within the applications development community once they are instantiated in the codes (as algorithms implemented in software) and executed as a part of the simulation tool. Specific and integral V&V are performed at a preliminary level by the code developers. The code is then released to early users while a more rigorous and independent assessment process is applied through the V&V Sub-program. Finally, when the tested code is provided to the designers, they apply their own suites, system by system, of integral tests that they perform to give them confidence that the current release meets their requirements for DSW work.

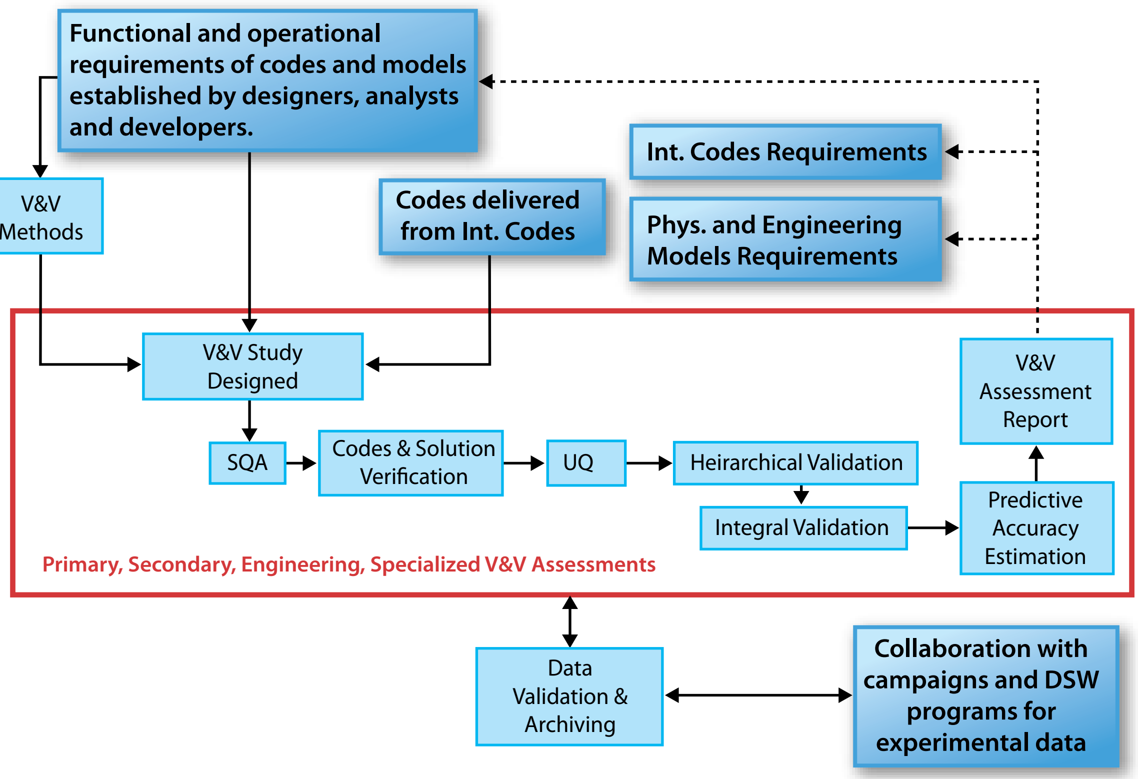


B.2—Physics and Engineering Models Process Flow Diagram

This cycle is repeated on an ongoing basis, as each release is documented and passed through a careful SQA process to meet agreed-upon standards. There are details that differ between code development teams and between organizations, but this process flow captures the major elements of the steps required to result in a usable and believable release.



B.3—Verification and Validation Process Flow Diagram



The V&V process focuses on the assessment of the scientific credibility of the ASC calculations for their intended use — weapons physics and engineering environments calculations. Validation ensures that the model represents physical reality, while verification ensures that the particular model is correctly implemented. Simulation V&V coordinates requirements from the design and analysis users, code releases from the Integrated Codes process, material and physics models from the Physics and Engineering Models process, and fundamental advances in understanding through the use of integral experimental data from Science Campaigns and DSW programs. Simulation V&V is distinct from the other processes in that it integrates across the other process flows, connecting the development and delivery of ASC capabilities to the design and certification programs, and provides a measure of confidence in the predictive capabilities in a structured, systematic framework.

The principal deliverables of the Simulation V&V process are systematic, thoroughly documented assessments of the performance of the integrated ASC tools and models as applied to representative integral physics and engineering weapons problems. These assessments include a quantitative assessment of simulation predictive capability, plus a description of issues, including the strengths and weaknesses of the codes and models for the applications of interest. These issues are then fed back into the requirements stage for the Integrated Codes and Physics and Engineering Models processes and documented for archiving and for the benefit of the end users of the tools. These assessments are hierarchical, in the sense that they span from the level of fundamental physical phenomena, to intermediate-level assembly behavior, to full-system device performance, with rigorous assessments of accuracy with respect to experimental data at each level. Uncertainties in both the simulation outputs and the experimental data are also generated and accounted for at each level and are a critical component of the accuracy assessments.

A particular aspect of the Simulation V&V process is that it is independent of both the code teams and the model developers. This independence allows the Simulation V&V assessments to be done in an atmosphere of due diligence and intellectual rigor. The assessments and issues identified then serve as input to the Integrated Codes or Physics and Engineering Models processes.

The process can be illustrated using four phases. A brief description of each phase is provided.

1. Software Quality Assurance: Serve as an advocate for sound SQE practices, as an educator of the code and model teams in sound SQE practices, and as an independent partner to assess and improve SQE practices with the code and model teams.

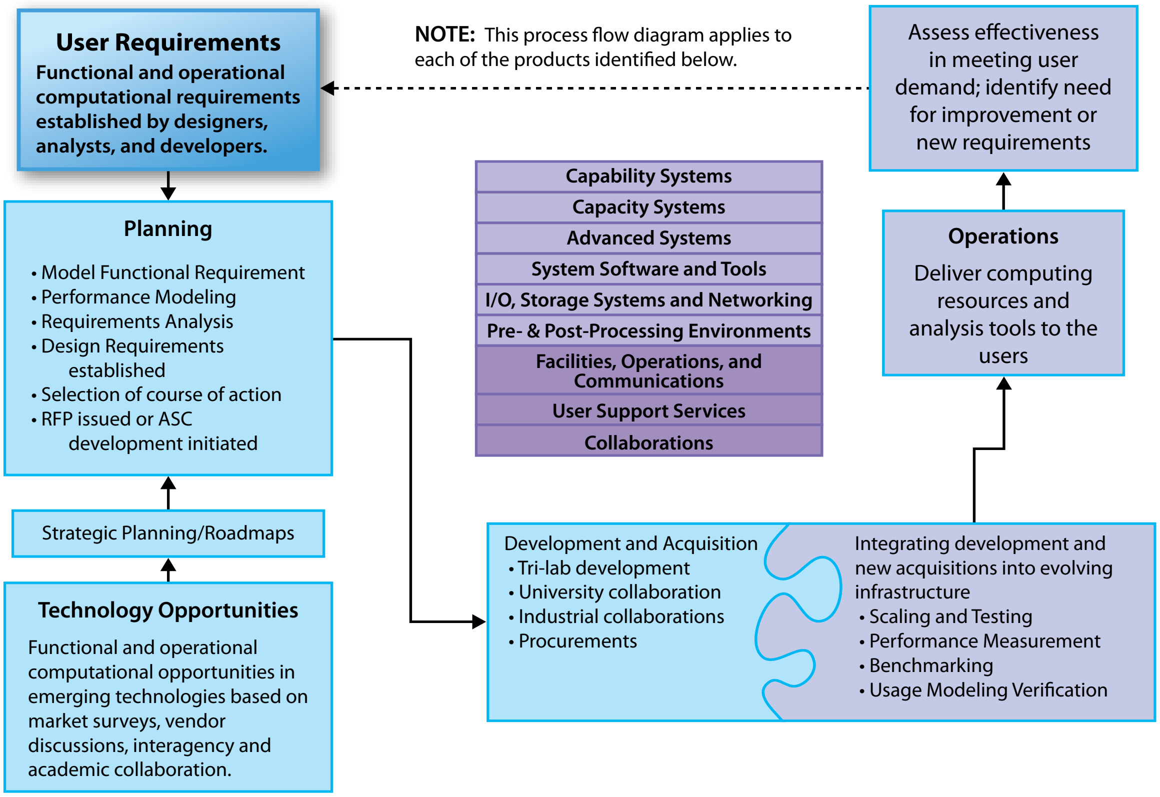
2. Code and Solution Verification: Develop and implement verification problems focused on the physics of interest (based on the priorities of the design and analysis communities), work with developers to integrate verification problems into code test suites, and acquire or develop tools and methods for verification (e.g., software to generate exact solutions, solution verification tools, code coverage tools).

3. Validation Assessment and Data Analysis: Define and execute hierarchical assessments of integral weapons physics and engineering problems, develop validation methods (e.g., validation metrics, surrogate test strategies), design and specify fundamental and integral validation experiments, document and archive validation experimental data, and re-analyze archival experimental data (e.g., Nevada Test Site data).

4. Uncertainty Analysis: Characterize uncertainties on fundamental model quantities (with the Physics and Engineering Models process), develop and implement methods to propagate uncertainties through integral calculations, estimate uncertainties from integral test data (both new and archive data), include uncertainties in validation assessments, integrate multiple sources of uncertainty for statistical assessment, and develop methods and tools for QMU to support certification efforts.

In summary, the Simulation V&V process develops a technically rigorous foundation for the credibility of the calculations performed using the ASC simulation tools and models, ensuring that they meet the needs of the certification, design, and analysis communities.

B. 4—Computational Systems and Software Environment/Facility Operations and User Support Process Flow Diagram



This diagram outlines the process used to provide a computing and simulation environment, integrating it into the fabric of available computing resources, optimizing performance and delivering cycles to the user. The integration of the Computational Systems and Software Environment Level-3 Sub-program with the Facility Operations and User Support Level-3 Sub-program accomplishes this mission. The process phases include research, development, deployment, operation, maintenance, and retirement (i.e., the full life-cycle management of the resource).

Appendix C. Glossary

Advanced Simulation and Computing Program

The goal of the Advanced Simulation and Computing (ASC) Program is to meet weapons assessment and certification requirements through leading edge, high-end computer simulation capabilities, including weapon codes, weapon science, platforms, and computer facilities.

Annual assessment and certification

Formal assessment of the systems in the existing stockpile and sending assurances to the President that no nuclear testing is required. Formal certification of the safety, reliability, and performance of modified or rebuilt devices.

ASC Executive Committee

Consists of two high-level representatives from each laboratory and Headquarters. The Committee sets overall policy for ASC, develops programmatic budgets, and provides oversight for the execution of the program.

Campaigns

Campaigns are directed at making the scientific and technological advances necessary to assess and certify weapon performance now and over the long term. They develop and maintain specific critical capabilities that are needed to sustain a viable nuclear deterrent.

Capability computing

The use of the most powerful supercomputers to solve the largest and most demanding problem, in contrast to capacity computing. The main figure of merit, metric, in capability computing is time to solution. In capability computing, a system is often dedicated to running one problem.

Capacity computing

The use of smaller and less expensive high-performance systems to run parallel problems with more modest computational requirements, in contrast to capability computing. The main figure of merit, metric, in capacity computing is the cost/performance ratio.

Design and Production Agencies

The national weapon laboratories and plants that make up the Nuclear Weapon Complex.

Directed Stockpile Work

Directed Stockpile Work supports the readiness of weapons and includes activities to meet current stockpile requirements. The effort includes weapon maintenance, comprehensive surveillance, weapon baselining, assessment and certification, supporting research and development, and scheduled weapon refurbishments.

DP

Defense Programs

DSW

Directed Stockpile Work

EOS

equation-of-state

FYNSP

Future Years Nuclear Security Program

HPSS

High-Performance Storage System

HSM

hierarchical storage management

ICF

inertial confinement fusion

I/O

Input/output, or data transfer

IP

Implementation Plan

Laboratory-Directed Research & Development

An internal laboratory program. It provides the directors of individual laboratories with flexibility to invest in long-term, high-risk, and potentially high-payoff research activities that enhance the science and technology capabilities of the laboratories.

Legacy Codes

Application codes that existed prior to the start of the ASC Program, before 1995. In many cases, Legacy Codes are no longer being actively developed.

Level 1

Different from Level 1 milestone; Level 1 for the national Work Breakdown Structure refers to Defense Programs, the organization within which the ASC Program exists.

Level 2

Different from Level 2 milestone; Level 2 for the national Work Breakdown Structure refers to the ASC Program itself.

Level 3

Level 3 for the national Work Breakdown Structure refers to the sub-programs that make up the ASC Program. Federal managers allocate funds to this level, unless the Program Director elects to allocate resources to a specific activity.

Level 4

Level 4 for the national Work Breakdown Structure refers to the products that the ASC develops and delivers. HQ federal managers collaborate with laboratory managers to plan product strategies. Federal management and oversight are primarily a concern at this level and the integration of the products. Level-4 Products are the culminated results of Level-5 Projects. Level-4 Products may be the result of single or multiple laboratory efforts. Sites can shift funds among Level-4 Products within the same Level-3 Sub-program. Beginning in FY07, costs at Level 4 will be reported on a monthly basis through the Department of Energy accounting system.

Level 5

Level 5 for the national Work Breakdown Structure refers to the projects that make up the technical work necessary to develop and deliver the Level-4 Products. The HQ federal managers are cognizant of the specific projects; however, the individual laboratories manage and execute them.

NAS

network-attached-storage

NECDC

Nuclear Explosive Code Developers Conferences

NNSA

National Nuclear Security Administration

nWBS

national Work Breakdown Structure

PFD

Process Flow Diagram

Predictive capability

Summary phrase to describe the ASC Program's strategy emphasizing a deeper understanding of the underlying science, a continual replacement of the phenomenology in the weapon simulation codes by better theoretical models, and a quantification of their limitations.

Process Flow Diagram

Graphical representation of the ASC sub-programs in terms of activities, infromation flow and interrelationships among tasks.

QMU

Quantification of Margins and Uncertainty

SAN

storage-area-networks

SLEP

Stockpile Lifetime Extension Program

SQA

Software Quality Assurance

SQE

Software Quality Engineering

SSP

Stockpile Stewardship Program

Stockpile

Warhead-types that equip strategic land, air, and sea-based forces with nuclear capability.

Stockpile Lifetime Extension

List of activities designed to extend the operational service life of an existing nuclear weapon by providing new subsystems and components.

Stockpile Requirements

Workload of ASC in support of the life-cycle management of nuclear weapons that includes, but is not necessarily limited to, annual certification, life extension programs, and significant finding investigations.

STRATCOM

U.S. Strategic Command (USSTRATCOM) controls operational commitment of strategic nuclear forces. STRATCOM provides the primary voice for strategic nuclear force structure, modernization, and arms control; it assures the integration of strategic nuclear policies; and it prepares for use if deterrence should fail.

STS

Stockpile-to-Target-Sequence

UQ

Uncertainty Quantification

V&V

Verification and Validation

Work Breakdown Structure

For ASC, it is the hierarchical representation of the total work of the program based on products and projects.

Work for Others

A DOE full-cost reimbursable research and technical assistance program that provides assistance to other federal agencies through DOE laboratories.

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

National Nuclear Security Administration