Appendix A: Level-1 Milestones

ASCI level-1 milestones are first listed in this section by an identification label, the quarter in which they are to be completed, and a title. Following that list, a brief description is provided of each milestone. Completed milestones are displayed as grayed text to show accomplishments. The identification label identifies the milestone in the following way: milestone "NA-2.1" is the first (".1") milestone to be completed in the area of Nuclear Applications ("NA") in the year 2002 ("2").

Nuclear Applications

NA-0.1 FY2000 Q1 Three-dimensional primary-burn prototype simulation (review completed January 10, 2000)
NA-1.1 FY2001 Q1 Three-dimensional secondary-burn prototype simulation (review completed August 1–4, 2000)
NA-2.1 FY2002 Q1 Three-dimensional prototype full-system coupled simulation
NA-3.1 FY2003 Q1 Three-dimensional high-fidelity-physics primary-burn simulation, initial capability
NA-4.1 FY2004 Q1 Three-dimensional high-fidelity-physics secondary-burn simulation, initial capability
NA-4.2 FY2004 Q4 Three-dimensional high-fidelity-physics full-system simulation, initial capability

Nuclear Safety

NS-2.1 FY2002 Q4 Three-dimensional safety simulation of a complex abnormal explosive-initiation scenario

Nonnuclear Applications

NN-0.1 FY2000 Q2 Three-dimensional prototype hostile-environment simulation (review completed May 23–24, 2000)
NN-1.1 FY2001 Q4 STS normal environment prototype simulation
NN-2.1 FY2002 Q4 STS abnormal environment prototype simulation
NN-3.1 FY2003 Q4 Coupled STS hostile environment simulation
NN-5.1 FY2005 Q4 Full-system STS environment simulation

Verification and Validation

VV-1.1 FY2001 Q2 Demonstrate initial validation methodology on the then-current state of application modeling of early-time primary behavior
VV-5.1 FY2005 Q1 Demonstrate initial uncertainty quantification assessments of ASCI nuclear and nonnuclear simulation codes

Materials and Physics Modeling

PM-2.2 FY2002 Q4 Delivery of initial macro-scale reactive flow model for high-explosive detonation derived from grain-scale dynamics

VIEWS

VU-0.1 FY2000 Q1 Prototype system that allows weapons analysts to see and understand results from three-dimensional prototype primary-burn simulations (review completed January 10, 2000)
VU-4.1 FY2004 Q4 Ability to do real-time analysis on an ASCI dataset

PSE

PS-1.1 FY2001 Q1 Initial software development environment extended to the 10-teraOPS system (completed pending review scheduled April, 2001)

DisCom2

DC-1.1 FY2001 Q2 Distance-computing environment available for use on the 10- teraOPS ASCI system
DC-3.1 FY2003 Q4 Complex-wide infrastructure that integrates all ASCI resources

Physical Infrastructure and Platforms

PP-0.1 FY2000 Q3 10-teraOPS system (*White*), final delivery and checkout (completed 09/00)
PP-2.1 FY2002 Q3 30-teraOPS system (*Q*), final delivery and checkout
PP-3.1 FY2003 Q4 20-teraOPS system (*Red Storm*), final delivery and checkout
PP-4.1 FY2004 Q1 60-teraOPS system (Lawrence Livermore), final delivery and checkout
PP-5.1 FY2005 Q2 100-teraOPS system (Los Alamos), final delivery and checkout

Appendix A: Level-1 Milestones

Nuclear Applications

→ All compared against tests ∴ node 76-1

NA-0.1 FY2000 Q1 review completed January 10, 2000

Three-dimensional primary-burn prototype simulation

By December 31, 1999, the ASCI project will make a prototype calculation of the explosion of a primary with three-dimensional engineering features. The simulation will produce relevant information, including a yield that will be compared to a nuclear test.

(A more detailed description of this milepost is available on request from the DP Office of Advanced Simulation and Modeling.)

NA-1.1 FY2001 Q1 review completed August 1–4, 2000

Three-dimensional secondary-burn prototype simulation

By December 31, 2000, the ASCI project will make a prototype calculation of the explosion of a secondary with three-dimensional engineering features. The simulation will produce relevant information, including a yield that will be compared to a nuclear test.

(A more detailed description of this milestone is available on request from the DP Office of Advanced Simulation and Modeling.)

NA-2.1 FY2002 Q1

Three-dimensional prototype full-system coupled simulation

By December 31, 2001, the ASCI project will make a prototype calculation of the explosion of a full weapon system (primary + secondary) with three-dimensional features. The simulation will produce relevant information, including the primary and secondary yields that will be compared to a nuclear test.

(A more detailed description of this milestone is available on request from the DP Office of Advanced Simulation and Modeling.)

NA-3.1 FY2003 Q1

Three-dimensional high-fidelity-physics primary-burn simulation, initial capability

By December 31, 2002, the ASCI project will make a high-fidelity-physics calculation of the explosion of a primary system with three-dimensional features. The simulation will produce relevant information, including the primary yield, that be compared to a nuclear test.

(A more detailed description of this milestone is available on request from the DP Office of Advanced Simulation and Modeling.)

NA-4.1 FY2004 Q1

Three-dimensional high-fidelity-physics secondary-burn simulation, initial capability

By December 31, 2003, the ASCI project will make a high-fidelity-physics calculation of the explosion of a secondary system with three-dimensional features. The simulation will produce relevant information, including the secondary yield that will be compared to a nuclear test.

(A more detailed description of this milestone is available on request from the DP Office of Advanced Simulation and Modeling.)

NA-4.2 FY2004 Q4

Three-dimensional high-fidelity-physics full-system simulation, initial capability

By September 30, 2004, the ASCI project will make a high-fidelity-physics calculation of the explosion of a full weapon system (primary + secondary) with three-dimensional features. The simulation will produce relevant information, including primary and secondary yields that will be compared to a nuclear test.

(A more detailed description of this milestone is available on request from the DP Office of Advanced Simulation and Modeling.)

(The development of this milestone was based on the original platform strategy that featured the availability of a 100-teraOPS platform for one year. As noted in the discussion under the Physical Infrastructure and Platforms section of this document, current budget projections have resulted in a new platform strategy wherein the 100-teraOPS system assumed to be available for this milestone has been replaced with a 60-teraOPS system available for much less than one year. The program is still reviewing the impact on this milestone of the revised platform strategy.)

Appendix A: Level-1 Milestones

Supporting the level-1 milestone are level-2 milestones that include:

- Subsystem electrical circuit simulation of AF. → MC2912 model
- Three-dimensional electromagnetic response of the radar fusing for radar front end and height of burst.
- Three-dimensional nonlinear dynamics for physics package response during re-entry.

In addition, this milestone will require support from all of the ASCI program elements. These activities include:

- From ASCI Platforms, support and availability on ASCI White. A stable production capable machine must exist three months prior to the completion of the level-1 aspects of this milestone.
- From ASCI DisCom^2, high speed network connectivity from Sandia to ASCI White.
- From ASCI PSE, stable DFS.
- From ASCI V&V, initial validation calculations of the existing material models.
- From ASCI M&PM, integration of subgrid models into ASCI codes.
- From ASCI Algorithms, mesh support from Cubit.
- From ASCI VIEWS, visualization support for large data sets and desktop visualization.
- From Weapon System Engineering Certification Campaign, support for validation experiments.

Verification of software will continue within ASCI Applications code team, and gathering of experimental data for mechanics and physics validation will continue as the central thrust of the Weapon System Engineering Certification Campaign. This level-1 milestone is critical to successful completion of a succeeding milestone for full STS simulation capability.

NN-2.1 FY2002 Q4

STS Abnormal Environment Prototype Simulation
(Thermal and Structural Safety Analyses [Crash and Burn])

This level-1 milestone will consist of a set of three three-dimensional calculations for an STS Abnormal Environment crash and burn accident involving a nuclear weapon. The level-1 milestone simulations will include three-dimensional system and component geometry, with subgrid physics models that have been validated at a preliminary level.

Calculations will be performed at certification resolution. The certification-level analyses will expand the accuracy of previous analyses via new capabilities such as mesh adaptivity, robust contact algorithms, and improved coupling of enclosure radiation and conduction.

The simulation capabilities will be under the software control of the Sandia ASCI application SIERRA framework. Three calculations addressing different aspects of a crash and burn accident will be completed.

1. Accidental Drop of Warhead: demonstrate transient dynamics capability for nonlinear multimaterials with robust contact to predict deformations resulting from an accidental drop for assessment of system structural integrity.
2. Pool Fire Accident (Weak Link/Strong Link Thermal Race): demonstrate nonlinear, multimaterial, multielement thermal conduction coupled with enclosure radiation to evaluate the weak link/strong link thermal race during a fire accident consisting of an engulfing or directed fire environment to be specified in terms of a heat flux. This simulation will include foam decomposition, robust contact, and adaptivity.
3. Pool Fire Accident (HE Chemistry Issues): demonstrate nonlinear, multimaterial thermal conduction coupled with enclosure radiation and HE chemistry to evaluate HE thermal decomposition during a fire accident to be specified in terms of a heat flux. This simulation will include robust contact and adaptivity.

Simulations should be performed on an ASCI supercomputer using a processor count that is appropriate for the size of the selected problem. In this context, "appropriate" means that enough processors have been used so as to obtain an acceptable execution time while maintaining reasonable parallel efficiency of the entire calculation. In addition, studies should be performed to determine the overall computational efficiency for a selection of problem

Nonnuclear Applications

NN-0.1 FY2000 Q2 review completed May 23-24, 2000

Three-dimensional prototype hostile environment simulation

This milepost will be a demonstration of ASCI software for three-dimensional dynamic response of a re-entry vehicle system to hostile radiation and blast environments. This initial simulation capability will include three-dimensional weapon geometry, but with limited physics, and limited physics and mechanics coupling. Included are models for the following hostile environments: (1) blast and impulse loading which can potentially result in structural damage to the weapon system and components; (2) photon radiation transport which can penetrate the weapon structure, depositing energy at critical component locations which can potentially result in thermal-mechanical damage; and (3) photon radiation transport which can penetrate the weapon structure, producing electrons which can potentially result in electrical damage to the components.

In this simulation we will demonstrate ASCI software for a typical re-entry vehicle in nuclear environments, but with limited physics to three scenarios above:

- Full three-dimensional re-entry vehicle structural response to blast and impulse loading with mesh discretization in sufficient detail to predict internal component shock response.
- Three-dimensional Monte Carlo determination of dose, and thermal-mechanical response of a typical weapon component.
- Simulations will be performed on the ASCI Red TOPS Supercomputer utilizing at least 2000 processors.

Verification of software will continue within ASCI Applications code team, and gathering of experimental data for mechanics and physics validation will continue as the central thrust of the Hostile Certification Campaign. This milepost is critical to successful completion of a succeeding milepost for full STS hostile simulation capability.

NN-1.1 FY2001 Q4

STS normal environment prototype simulation

This level-1 milestone will be a demonstration of ASCI software for key three-dimensional mechanical responses of a re-entry vehicle system to normal flight environments. Supporting this milestone will be level-2 milestones that demonstrate the electrical response and other mechanical responses of a re-entry vehicle system to normal flight environments. This initial simulation capability will include three-dimensional weapon geometry, but with limited mechanics and physics. Level-1 milestone capabilities include:

- **Launch & Re-Entry:** Three-dimensional vehicle structural response including eigen-solutions for launch, nonlinear implicit transient dynamics for re-entry body separation shock, and re-entry random vibration. Key nonlinear features such as joint interface models required to capture the essential dominant structural response will be included.
- **Impact:** Three-dimensional shock physics and electromechanical response of contact fuse operation at termination of flight.

Simulations should be performed on an ASCI supercomputer using a processor count that is appropriate for the size of the selected problem. In this context, "appropriate" means that enough processors have been used so as to obtain an acceptable execution time while maintaining reasonable parallel efficiency of the entire calculation. In addition, studies should be performed to determine the overall computational efficiency for a selection of problem sizes and processor counts. To minimize execution times, these studies may be performed for brief time intervals or subsets of the problem's physical models, or both. The intent of these studies should be to reveal what ranges of processor counts yield efficient machine utilization as a function of problem size.

sizes and processor counts. To minimize execution times, these studies may be performed for brief time intervals or subsets of the problem's physical models, or both. The intent of these studies should be to reveal what ranges of processor counts yield efficient machine utilization as a function of problem size.

Level-2 milestones that will support this level-1 milestone are:

- Validation of the polyurethane foam decomposition model and HE decomposition models including V&V support for validation simulations and Weapon System Engineering Certification Campaign support for experiments.
- Mesh support from Cubit for detailed structural and thermal models.
- Visualization support for large data sets and desktop visualization.
- ASCI code development for Calore (thermal analysis: parallel contact, adaptivity, element death).
- ASCI code development for Presto (explicit dynamics: material models, element death, parallel contact).
- ASCI code development for Sierra framework (load balancing, I/O for topological changes in mesh, element death with inherited boundary conditions for meshes including shells).

In addition, this milestone will require support from all of the ASCI program elements. These activities include:

- From ASCI Platforms, a stable production capable machine must exist three months prior to the completion of the level-1 aspects of this milestone.
- From ASCI DisCom^2, high speed network connectivity from Sandia to other ASCI platforms.
- From ASCI PSE, stable DFS.
- From ASCI V&V, initial validation calculations of the existing material models.
- From ASCI M&PM, integration of subgrid models into ASCI codes.
- From ASCI Algorithms, mesh support from Cubit.
- From ASCI VIEWS, visualization support for large data sets and desktop visualization.
- From Weapon System Engineering Certification Campaign, support for validation experiments.

Verification of software will continue within ASCI Applications code team, and gathering of experimental data for mechanics and physics validation will continue as the central thrust of the Weapon System Engineering Certification Campaign. This level-1 milestone is critical to successful completion of the FY2005 milestone for full STS simulation capability.

NN-3.1 FY2003 Q4

Coupled STS hostile environment simulation

This level-1 milestone will be a demonstration of ASCI software to compute the three-dimensional coupled mechanical response of a weapon system in hostile (nuclear) environments. The level-1 milestone capabilities will be demonstrated in four types of calculations:

1. Three-dimensional blast.
2. Three-dimensional impulse.
3. Thermo-structural response coupled with three-dimensional Monte Carlo radiation transport determination of energy deposition.
4. Three-dimensional adjoint Monte Carlo radiation transport determination of dose.

For blast, impulse, and thermo-structural response, a full three-dimensional model of the re-entry vehicle will be used with mesh discretization sufficient to resolve shock response and thermo-structural response in critical weapon components. For radiation transport, geometry information will be obtained from full three-dimensional CAD models of the weapon system.

Integration into an architectural framework, to accommodate alternative solver strategies and datasets employed,