Sandia Labs Support Operation Burnt Frost

Operation Burnt Frost Team

Used Red Storm's HPC capability to:

- Quantify the Lethality of the SM3 Kill Vehicle against the Satellite
- Provide estimates of Satellite debris from the intercept
- Assist in Kill Assessment based on the physics-based modeling of the post-intercept debris (as seen by radars)

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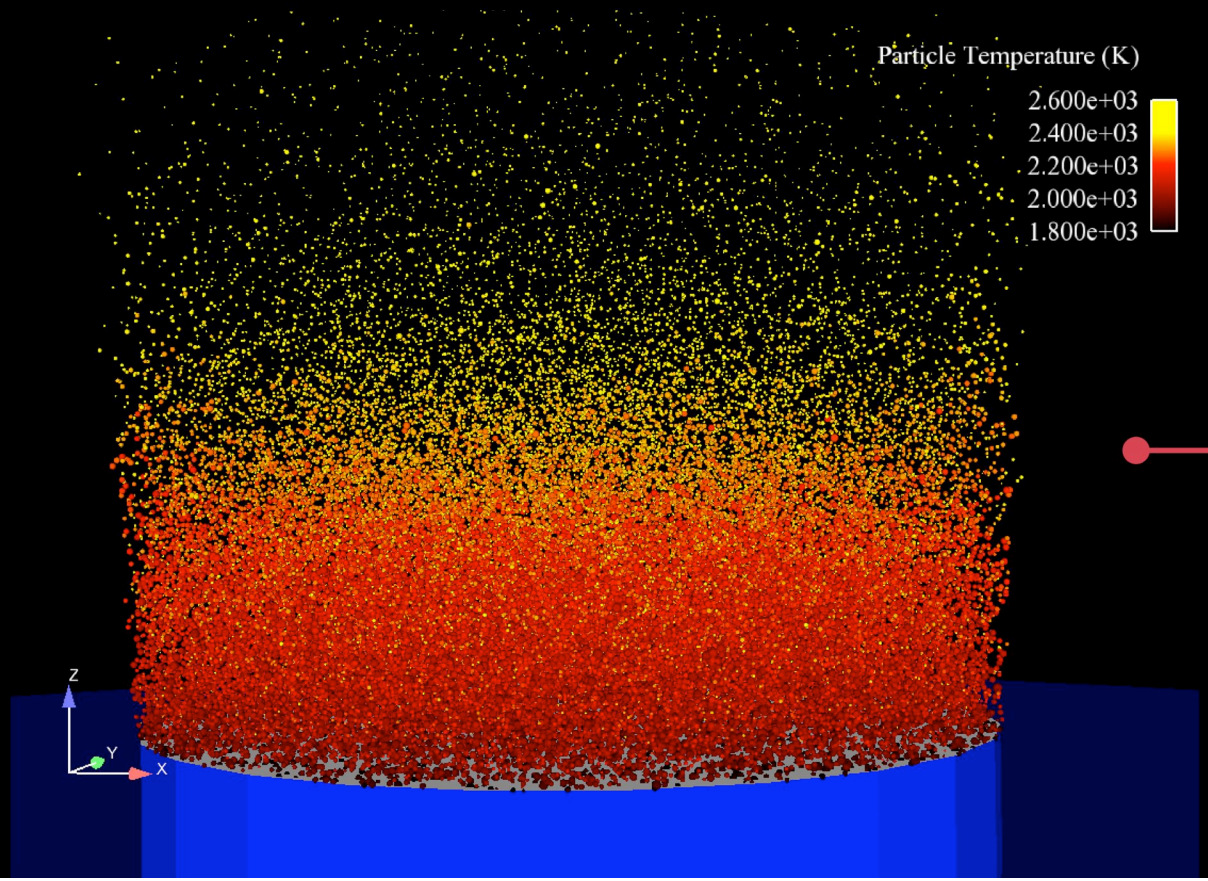
Modeling Solid Propellant Fires With Fuego



Each particle:

- is entrained by the high velocity gas flow
- heats up via radiation and convection
- evaporates (diameter decreases) and combusts or deposits

Lagrangian burning aluminum particles added to SIERRA/Fuego turbulent reacting flow code

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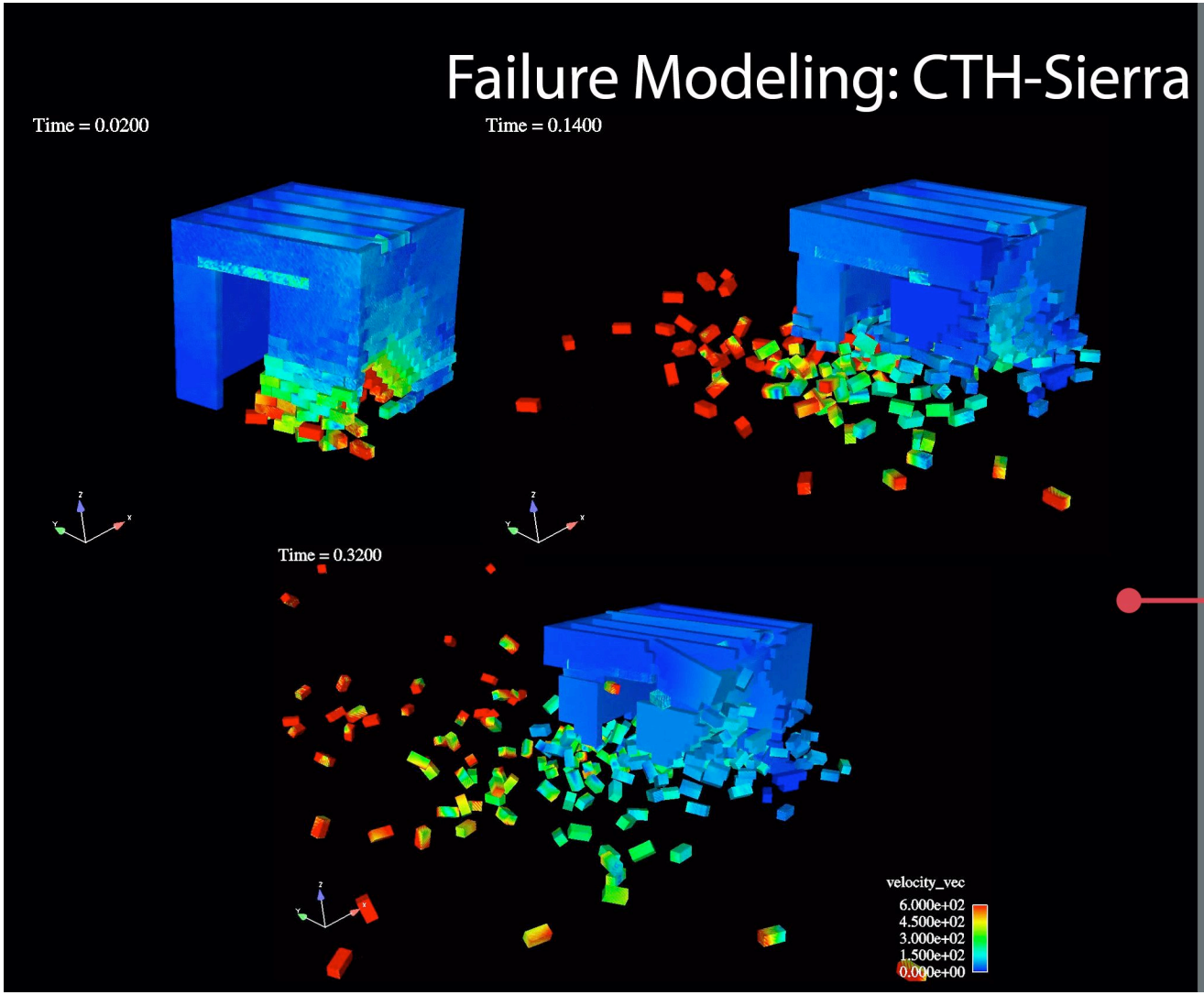
Failure Modeling: CTH-Sierra Coupling



CTH is coupled to Sierra Mechanics to provide Blast Loading and Structural Damage Response as illustrated in this blast on a building example

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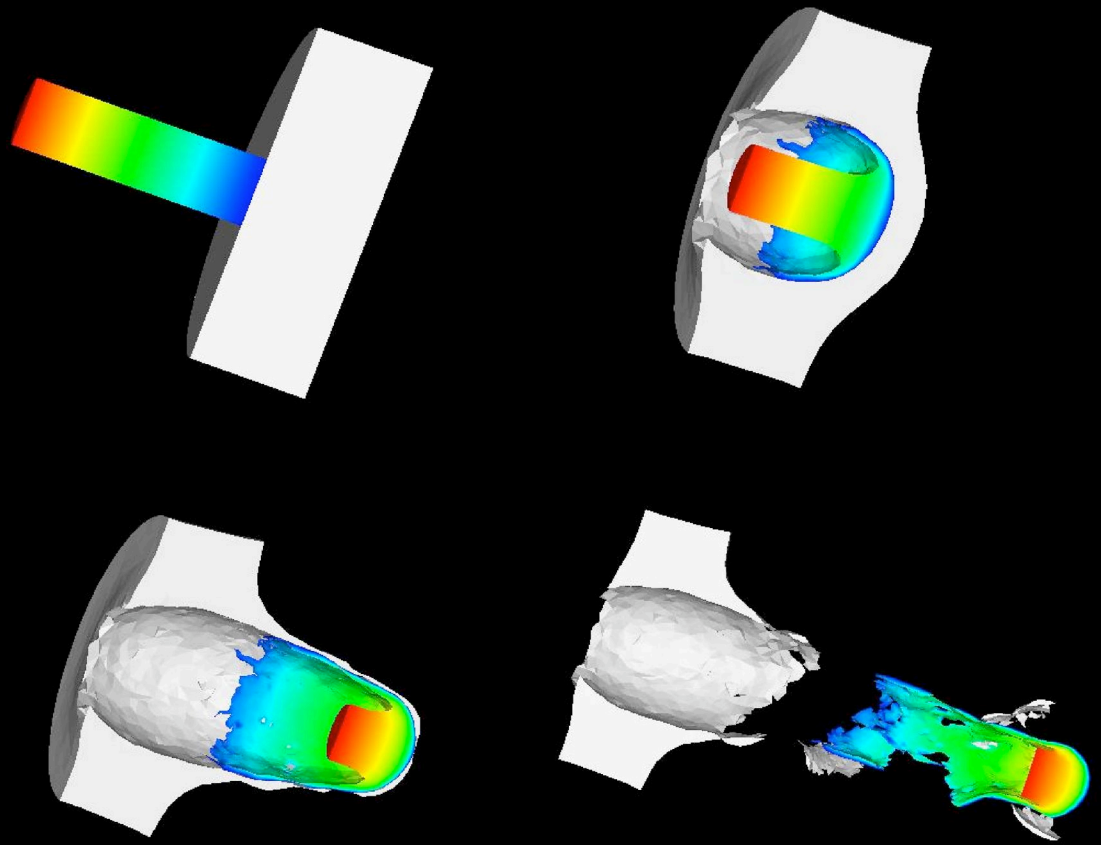
Failure Modeling: Nodal Based Tetrahedral Element with Automatic Remeshing



Nodal Tetrahedral Element w/ Automatic Remeshing provides a new capability to capture extremely large deformations and high strains in a Lagrangian framework shown in this tungsten rod impacting a steel plate simulation

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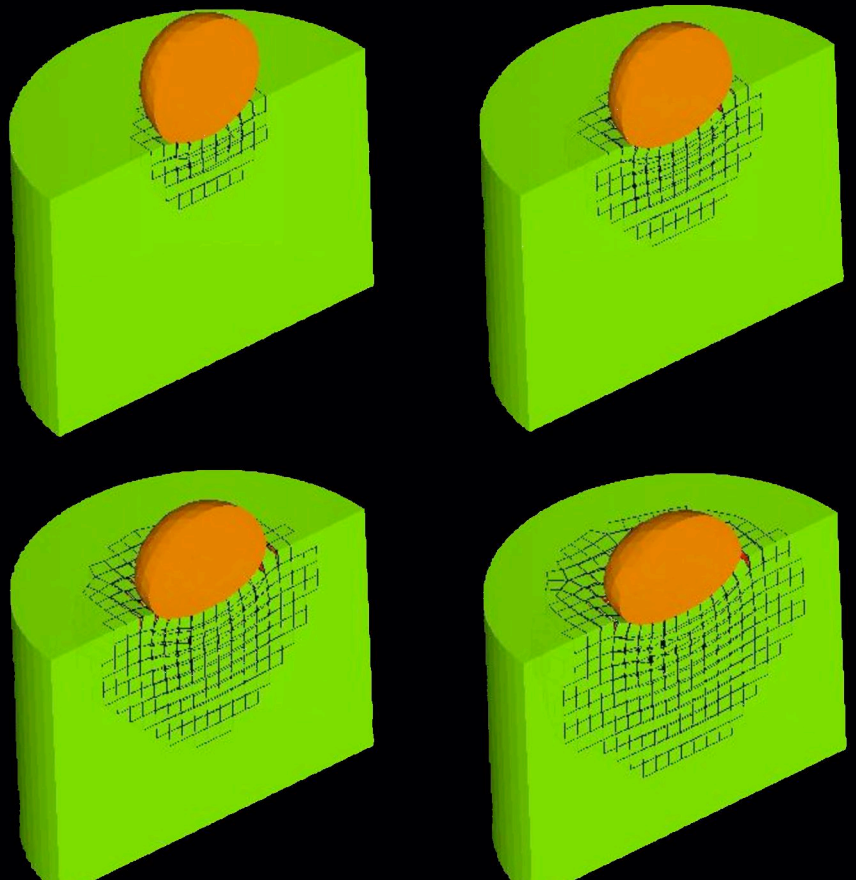
Failure Modeling: Dynamic Cohesive Zone Insertion



Dynamic Cohesive Zone Insertion offers the ability to separate finite elements upon material failure as shown in this impact example

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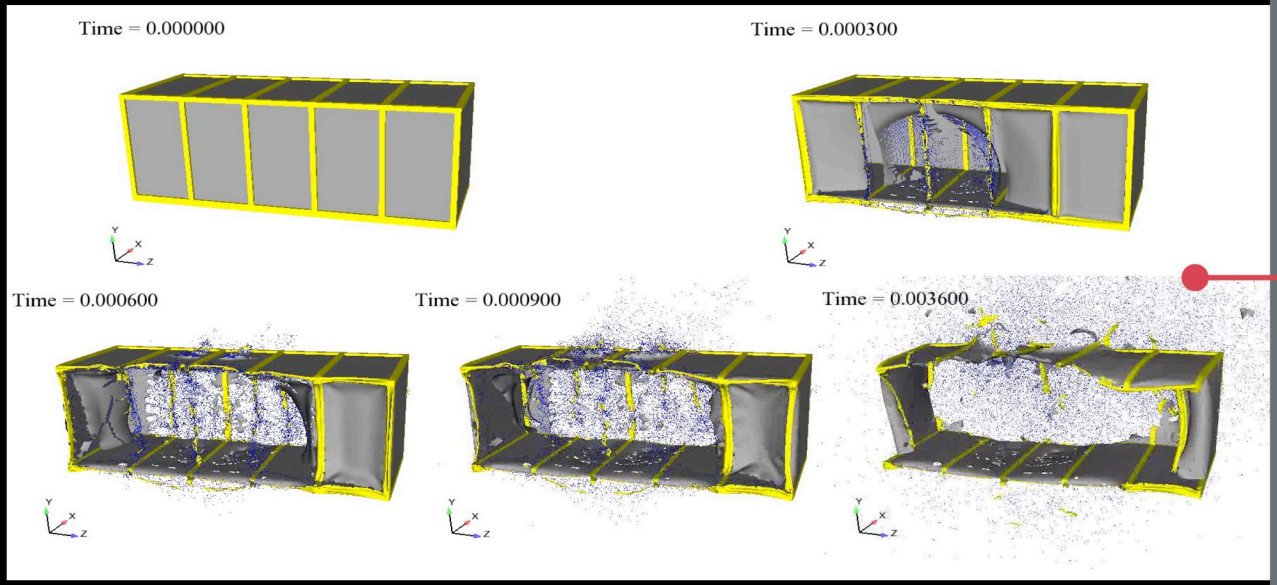
Failure Modeling: Element to Particle Conversion upon Failure



Element to Particle Conversion upon material failure allows the kinetic energy of failure material to remain in the simulation and to induce subsequent continuing structural damage as shown in this blast on box structure simulation

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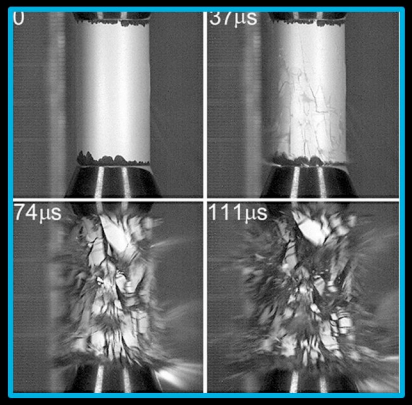
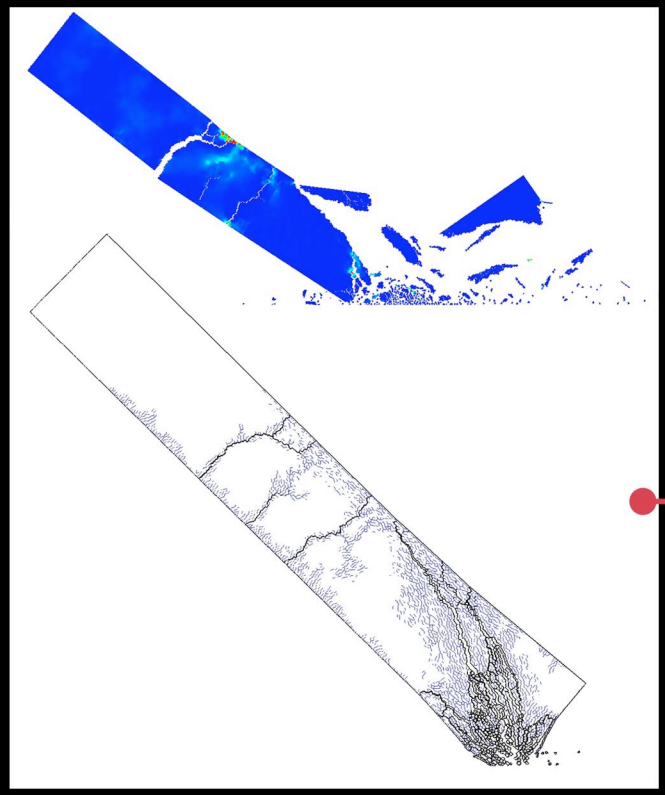
Simulating the Pervasive Failure of Structures

Blast induced structural collapse



Dynamic pervasive fracture



Concrete column striking a rigid wall

- Develop a computational method for modeling pervasive fracture and fragmentation.
- Method should be convergent with discretization refinement.

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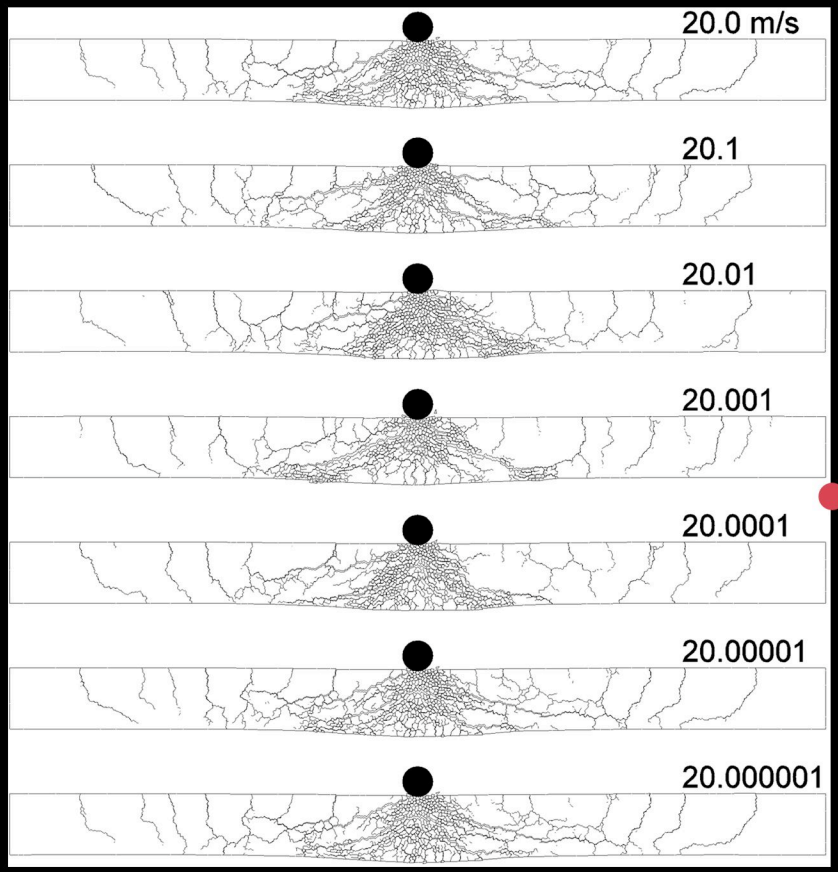
Simulating the Pervasive Failure of Structures

Sensitivity to Initial Conditions and Limits to Predictability

Note the extreme sensitivity to initial conditions in fracture patterns.

increasing precision in striking velocity



Rigid sphere striking a concrete column

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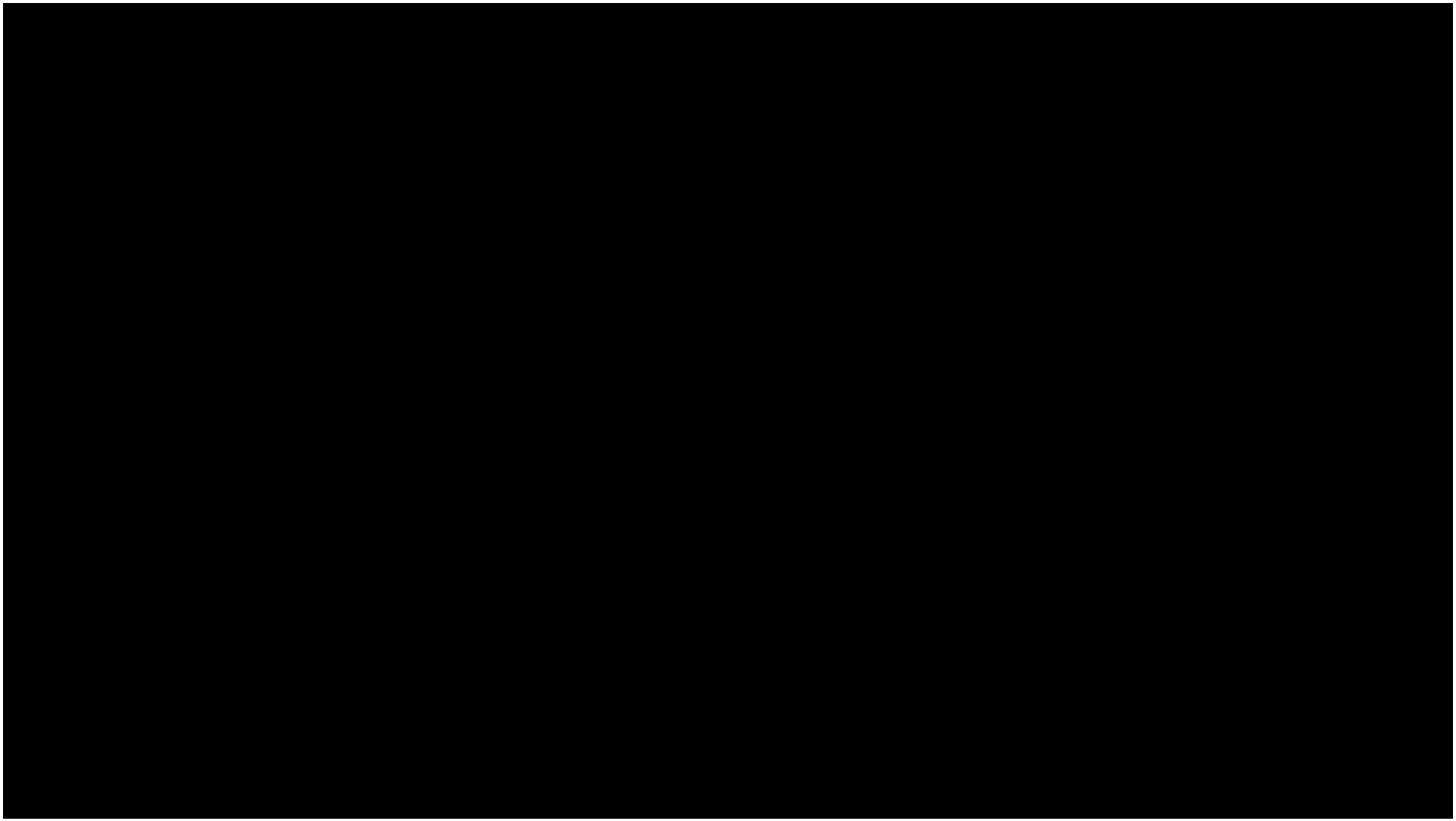
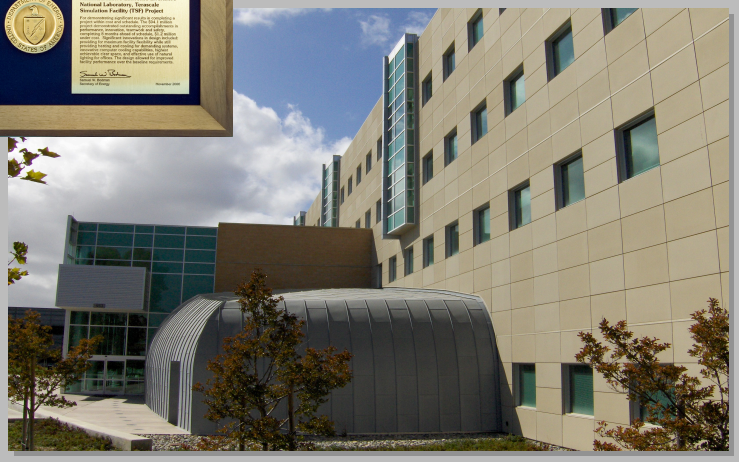


The Terascale Simulation Facility is a world-class supercomputing center housing some of the fastest computers in the world

DOE Secretary's Award of Achievement



TSF is designed to be home for multiple generations of supercomputers

- **Machine floor**
  - 48,000 ft^2 unobstructed floor (~4,500 m^2, ~0.45 hectare)
  - 15 MW machine power (30 MW upgrade planned)
  - 2,720,000 cfm air handling (~77,000 m^3/min)
  - 6675 tons of AC (~80M BTU/hr)
- **Four-story office tower**
  - 285 offices, visualization theater, 150-seat auditorium, small machine floors
  - 121,600 ft^2 (~11,300 m^2)

BlueGene/L—recaptured American predominance

"Green" supercomputer
reduces energy footprint by 75%

- 596 teraFLOPS peak speed
- 69 TiB aggregate memory
- 1.9 PB aggregate global disk
- 35.6 GB/s delivered input/output bandwidth
- Dual PowerPC 440 microprocessor technology
- 1664 x 1-Gb/s Ethernet external networking
- 106,496 dual-processor nodes
- 212,991 processors
- 104 racks

ASC Purple—dedicated to capability computing

- 100 teraFLOPS peak speed
- 50 TiB memory
- 2.88 PB disk space
- 132 GB/s input/output bandwidth
- 1,536 nodes
- 12,288 processors
- 269 racks

Purple is operated as a national user facility and realizes the goal of the first 10 years of the ASCI Program

TLCC—three labs leveraging common high-performance computing cluster hardware and software

JUNO is the TLCC system for LLNL with a peak of 166 teraFLOPS

- **Tri-Lab Linux Capacity Cluster**
  - Single purchase contract
  - Common software environment
  - Appro to deliver at least eight scalable Linux capacity clusters to tri-lab community
  - Aggregate peak of at least 438 teraFLOPS
  - Reduced costs to program, simplified integration, accelerated deployment

Sequoia is an uncertainty quantification engine and will enable tens of simultaneous Purple-class simulations

Sequoia supports quantified 3D predictive capability required for our national security missions

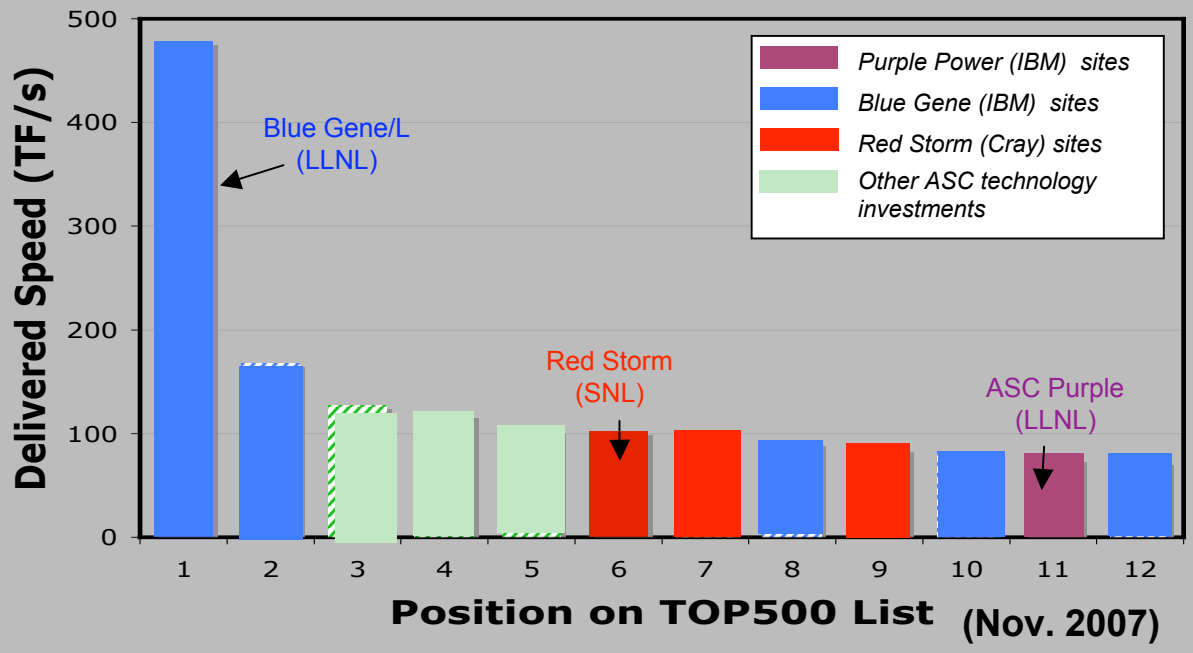
- Sequoia is targeted for production in the 2011-2016 time frame
  - 24x Purple on integrated multi-physics codes
  - 20x BlueGene/L on weapons science codes
- The Terascale Simulation Facility will provide an ideal home for Sequoia
  - 30 MW power
  - Efficient cooling
- We are working in partnership with our development teams to assure that our main simulation codes will be ready for Sequoia

The science in our state-of-the-art simulations is recognized in scientific publications around the world

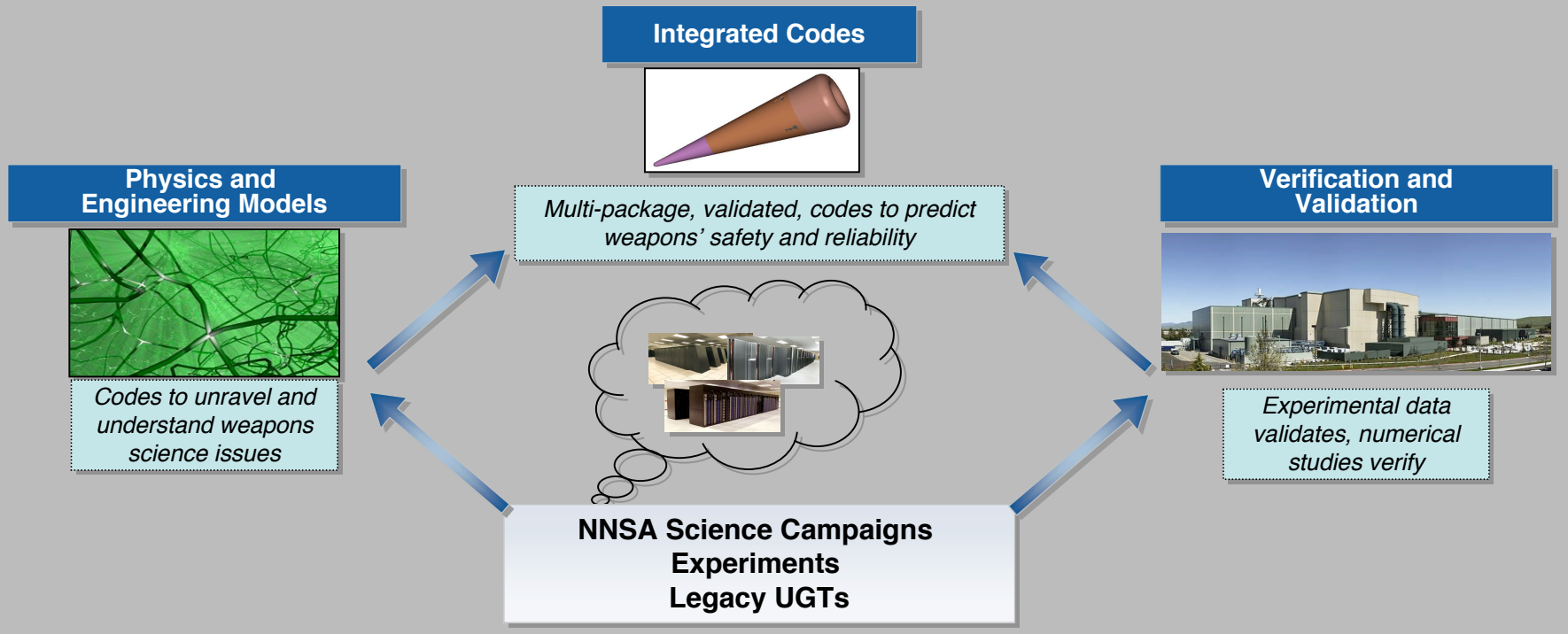
America's dominance in simulation today is the result of NNSA's investments and its astute technical choices

Today's TOP12 supercomputers *depended on NNSA investments*

37% of the TOP500 systems today *depended on ASC technology investments*

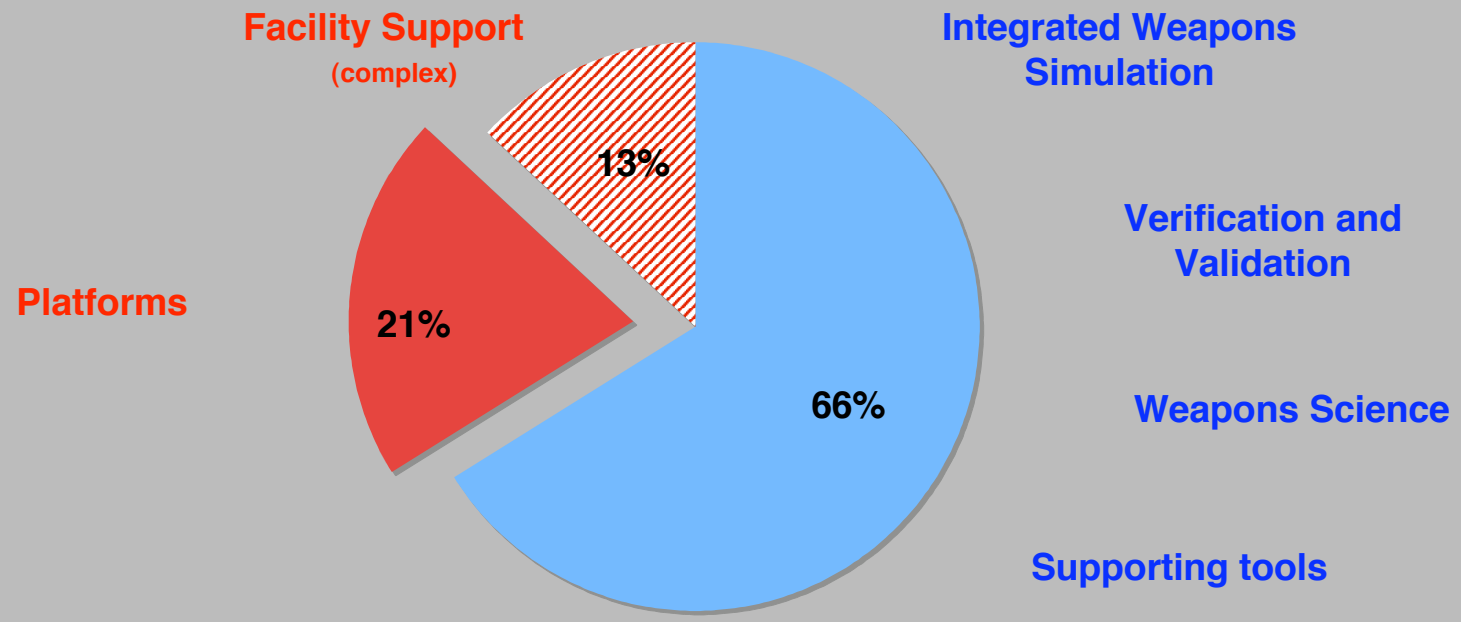


The Advanced Simulation and Computing (ASC) Program delivers high confidence prediction of weapons' behavior without nuclear tests



ASC integrates all of the science and engineering that makes stewardship successful

The ASC Program focuses primarily on software and its validation



Computing platforms and their support represent only about 1/3 of our investment