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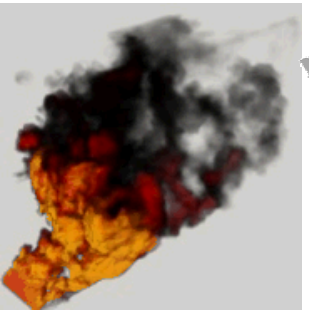

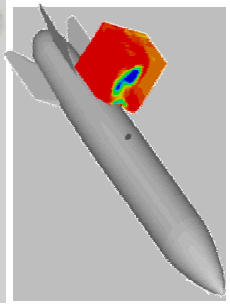

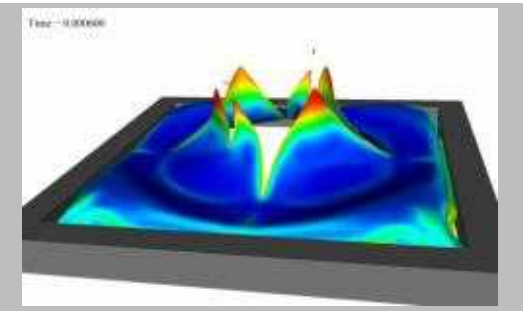

ESRF Strategy: Research Crosscuts

External Panel Review

David E. Womble

Senior Manager, Computational Simulation Group

Sandia National Laboratories

Exceptional service in the national interest

U.S. DEPARTMENT OF ENERGY NNSA

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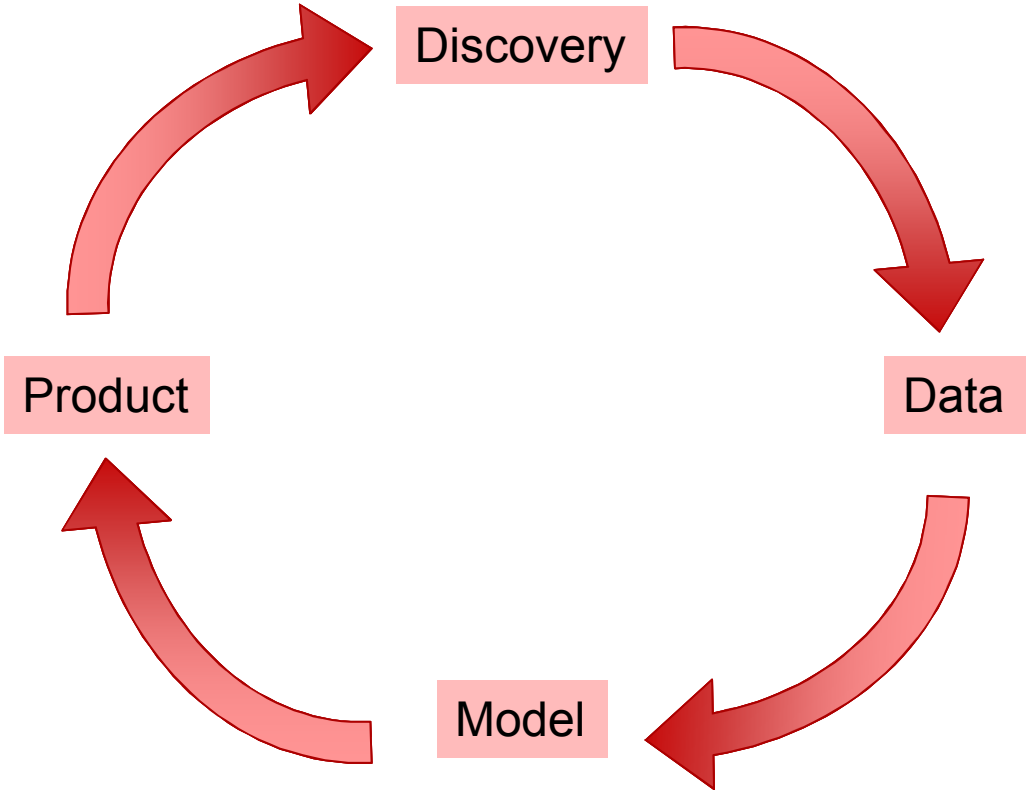
The ESRF Strategy has identified three "crosscutting" research areas

Sandia National Laboratories

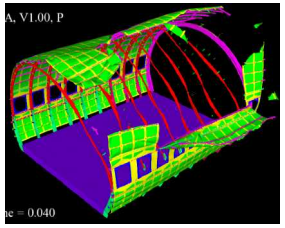
- Three crosscuts
  - Algorithms and Models for Computational Simulation
  - Novel diagnostics for Experimental Discovery and Validation
  - Integration for Validated, Predictive Assessments
- The goal is to
  - Impact the mission challenges with specific research investments
  - Identify and invest in "game-changing" research
- Implementation strategy is
  - Primary investment is through LDRD
  - Some additional investments from other programs (e.g., NW) or customers (e.g., DoD)
  - Tight coordination and joint investments are necessary since most programs think in terms of mission challenges

We think in terms of a cycle for identifying research and moving that through to impact.

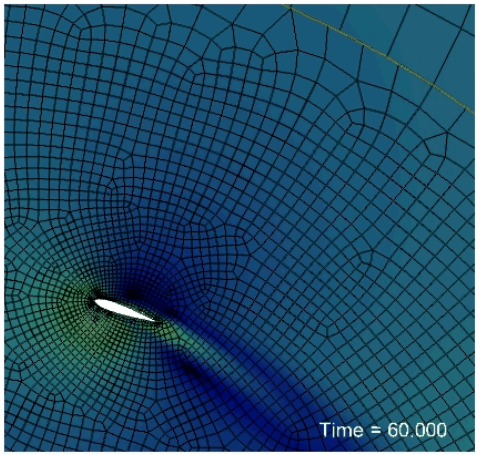


Historic investments have provided a world-class foundation in algorithms and models

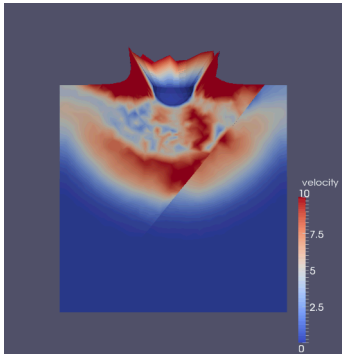
- For example,
  - Sierra and RAMSES suites provide integrated simulation capabilities with many Sandia-developed high-fidelity material models
  - Cubit, Dakota and Workbench provide and integrated workflow with meshing and post-processing capabilities



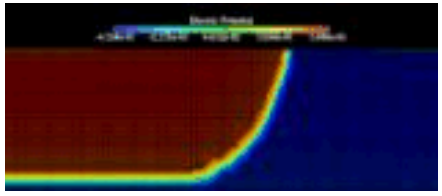
CTH



Sliding meshes in aerodynamics



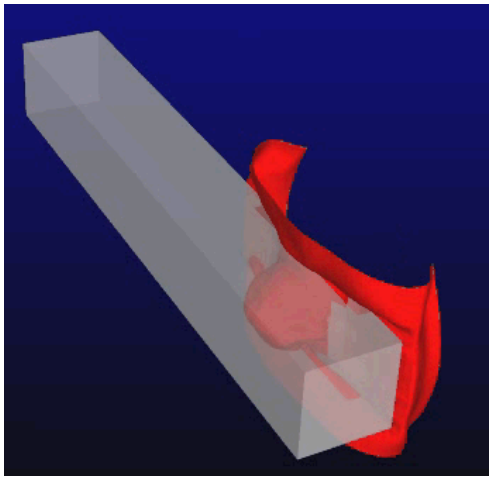
XFEM used to model frictional contact



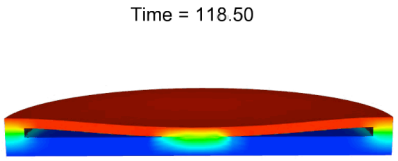
RAMSES (Radiation and Electrical

Research challenges in algorithms and models include the following:

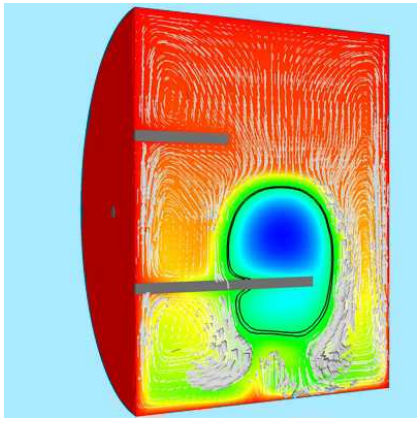
- Multiple scales
- Multiple physics and coupling
- Contact, fracture and failure
- Turbulence and chemistry
- Optimization and design
- Reduced order models



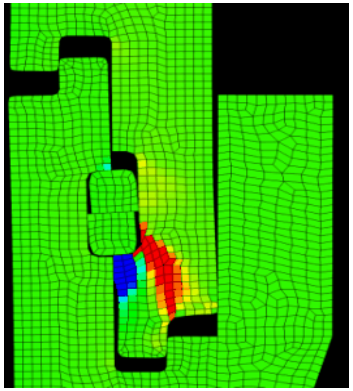
Blast on structure coupling



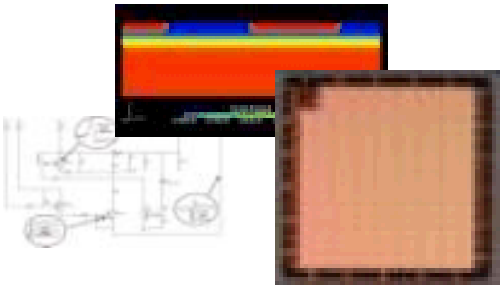
Thermal-mechanical coupling



Energetic materials

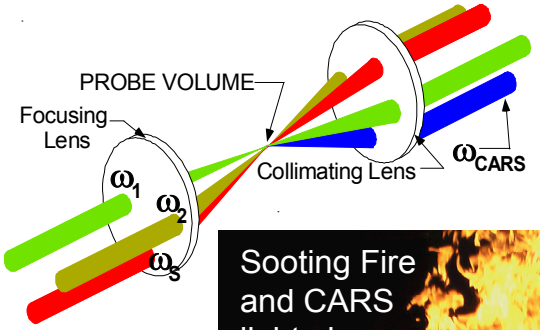


Joint failure

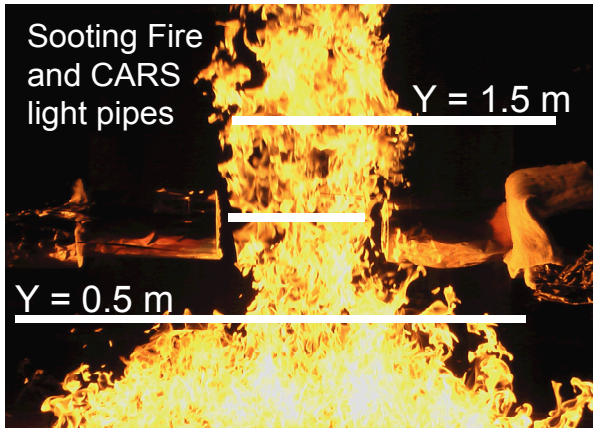


Radiation effects in electronics

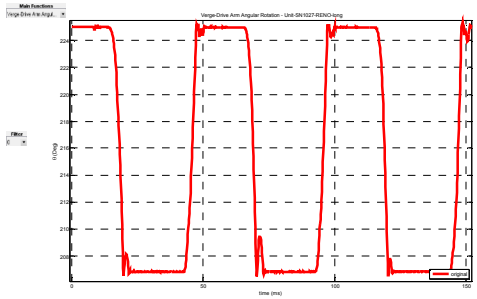
Our past investment in diagnostics (e.g., laser diagnostics and …) continues to pay off

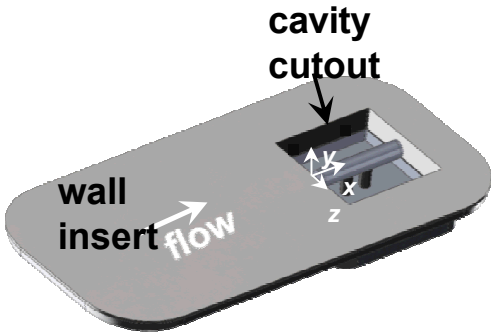


Coherent Anti-Stokes Raman Scattering (CARS)

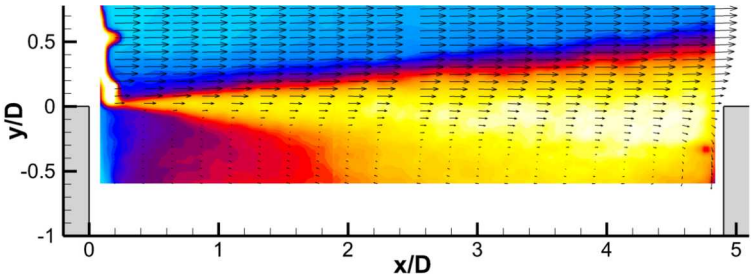


Digital Image Correlation is used to track motion in high-speed videos



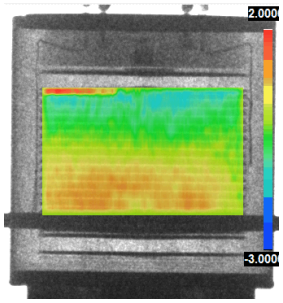


Time-correlated turbulence intensity in the shear layer, pressure loading, and store response

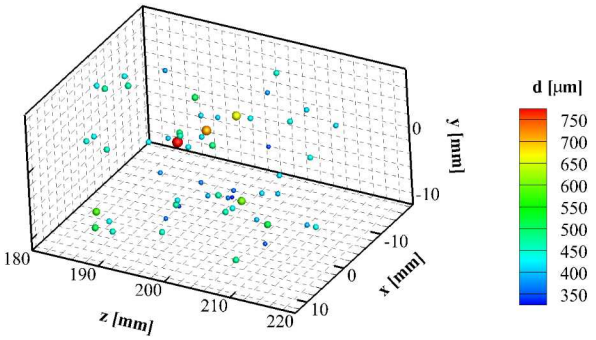


Diagnostic is an important investment area, including research challenges.

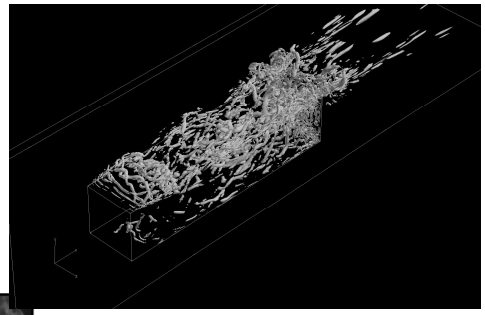
- 3-D Velocity and fragment morphology/droplet characterization in harsh/opaque environments
  - Ballistic imaging
  - Turbulence/density gradients, soot, fragment fields
- High-speed correlated multi-frame imaging
  - Time-correlated PIV
- Non-optical dynamic imaging
  - High-speed magnetic imaging
  - 3-D X-ray imaging
- Wireless sensing technologies
  - High-frequency, low-mass, robust technologies
- Digital Image Correlation (DIC) in Turbulent Media (e.g., fire)

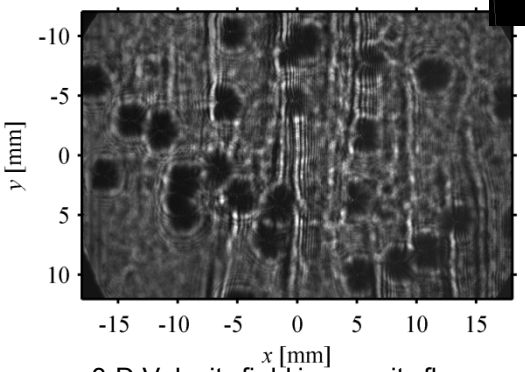


Moire' analysis of X-ray images to yield strain data in activated battery



Reconstructed 3D Position and size of particles





3-D Velocity field in a cavity flow

Hologram of shotgun pellets

Downward burn of Star 48 solid rocket propellant

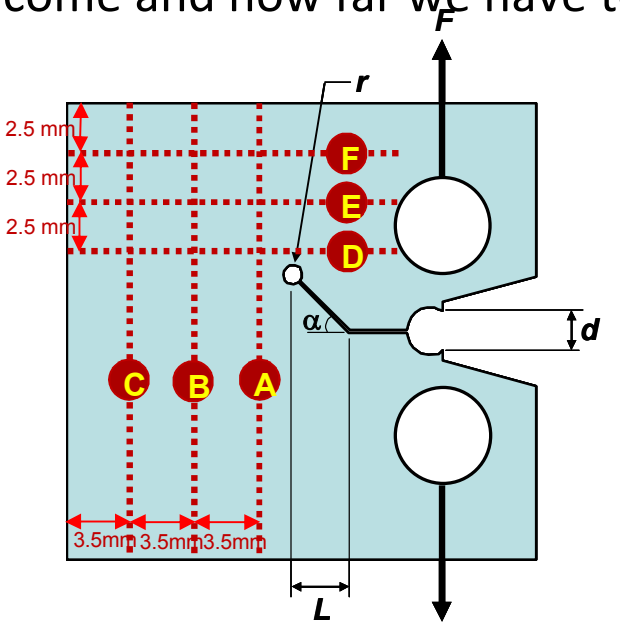
We have made a lot of progress combining physical and computational simulation

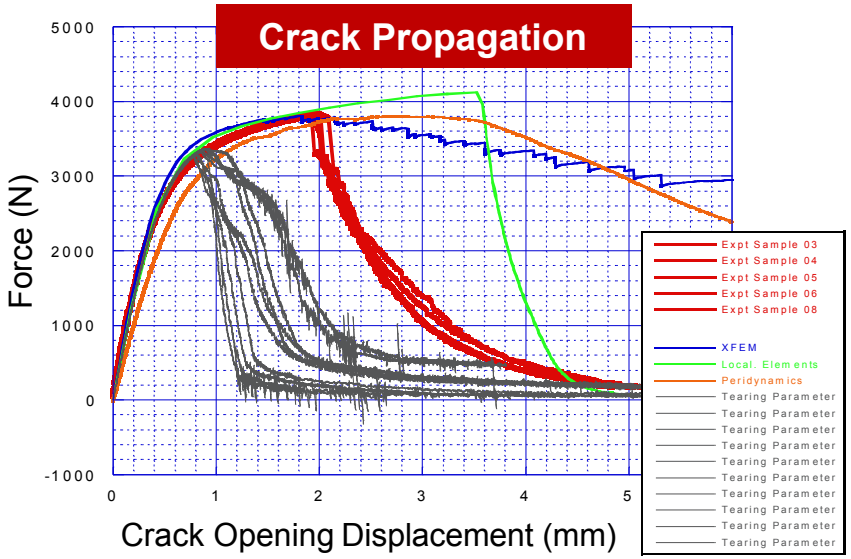
- Model development and validation
- Test design and optimization
- Quantifying uncertainties

- The X-prize shows both how far we have come and how far we have to go

For the specimen shown below

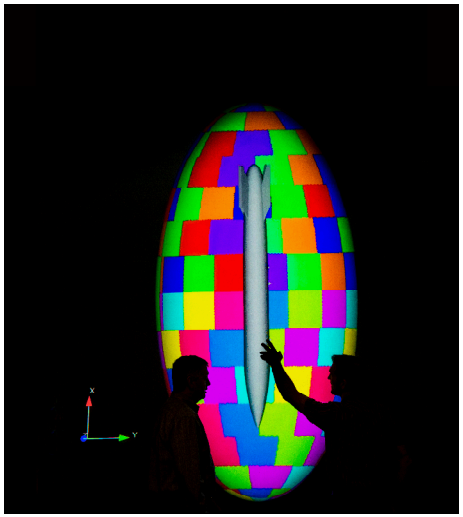
- What is the *load-line displacement* Δd and the *peak force* prior to crack initiation?
- What is the *order of crack propagation* (e.g. A-B-D-C, etc.)?
- What is the *force* and *displacement* at which the crack reaches the 1st line?
- What is the *force* (kN) and load-line *displacement* (mm) at which the crack reaches line E?





Continued investments in coupling physical and computational simulation target risk-informed decision making.

- Verification and Validation (and make it intrinsic)
  - Experimental design
  - Find appropriate quantities of interest
  - Dealing with grid dependencies and sensitivities
  - Estimating both computational and experimental uncertainties
- “Predictivity”
- Reduced-order models and surrogates
- Full life cycle (cradle-to-grave) engineering
  - Environmental specification for design
  - Design
  - Qualification and testing
  - Manufacturing and infrastructure
  - Surveillance and maintenance
  - Decommissioning



Summary

- Sandia makes cross-cutting research investments to provide a foundational capability for addressing mission challenges. And while much of the research can be viewed as general purpose, there is also a significant investment in making sure that this research is applicable to the challenges.

- We have state-of-the-art simulation and diagnostics capabilities, but to solve future mission challenges will require the effective integration of these two “sub-disciplines” with a focus on risk-informed decision making.