SAND2007-2468P

Embedding Modeling and Simulation in the NW Engineering Process

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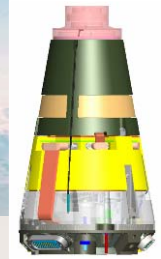
My Objective

Fully embed the use of computational simulation in nuclear weapon product engineering lifecycle processes

Purpose of This Meeting

- **Communicate my expectation that computational simulation will be fully embedded in nuclear weapon product engineering lifecycle processes, starting today**
- **Explain why it is important that we do so**
- **Unequivocally state my commitment to do all I can to support you as you make this happen**

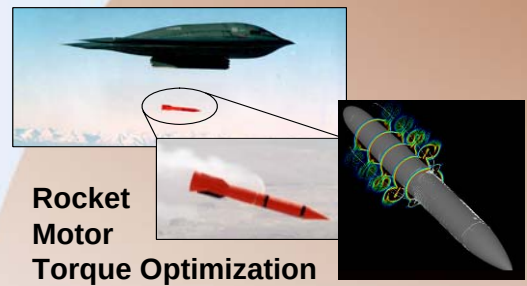
Nuclear weapon product engineering at Sandia has been very successful for decades…



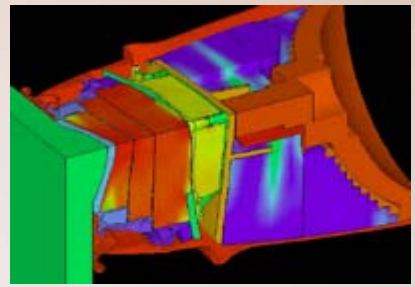
…relying on physical and computational simulation

Expected Benefits From Embedded Use of Computational Simulation

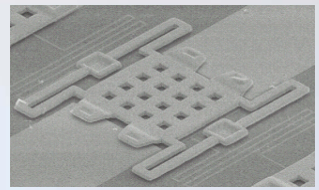
- Set the standard for the application of science-based engineering
- Understand product performance as much possible and as early as possible in the design process
- Quantification of product performance margins and uncertainties in all environments
- Accelerate product engineering innovation while reducing risk
- Improve agility, efficiency and responsiveness



Rocket Motor Torque Optimization



Nose Crush Analysis



MEMS Component Design

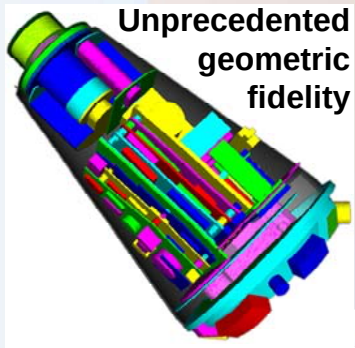
Investments Over the Past Decade Enable Embedded Use of Computational Simulation

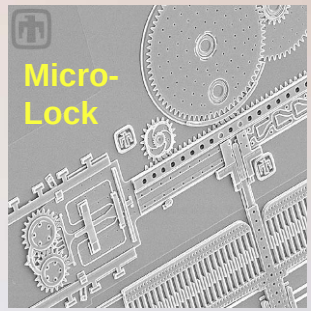
Billion-dollar investments in

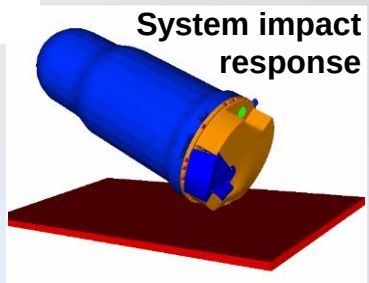
- **Material models**
- **Computing architectures**
- **Code development**
- **Code validation**
- **Visualization tools**

Enable "predictive" engineering

- **Improved phenomenological understanding**
- **New physical simulation facilities**
- **Simulations with unprecedented fidelity and detail**







Conceptually, Think of the Following Model: Conceive, Understand, Build

Conceive – confluence of technical innovation and product requirements

- **Develop conceptual design based on understanding of requirements and their impact on product design and performance**

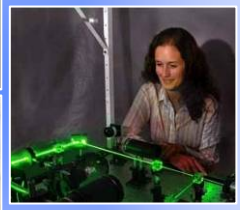
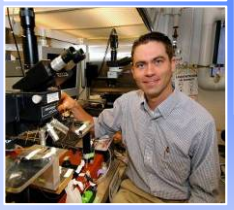
Understand – establish the technical basis for assured product performance

- **Detailed understanding of product performance and important physical phenomena - acquired & applied as *early as possible***
- **Identify & fill critical gaps in understanding of performance**
- **Embed phenomenological understanding in predictive computational simulations**

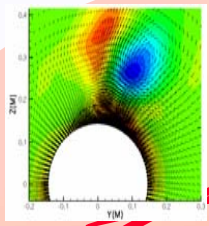
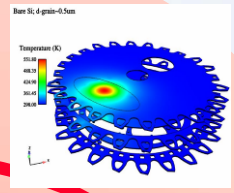
Build – Realize product and verify performance via computational and physical simulation

Computational and Physical Simulation are Essential Complementary Tools

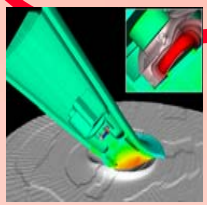
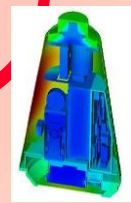
Research
establishes scientific understanding

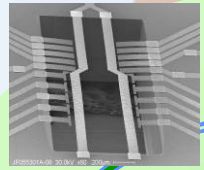




… and forms the basis for the physical models used in computational simulations

Computational Simulation

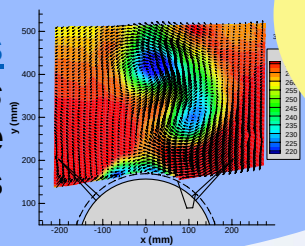


Product Engineering




Advanced Computational Platforms
provide both capacity and capability computing

Experiments
validate the models
used in the umerical simulations



Physical Simulation
validates design intent



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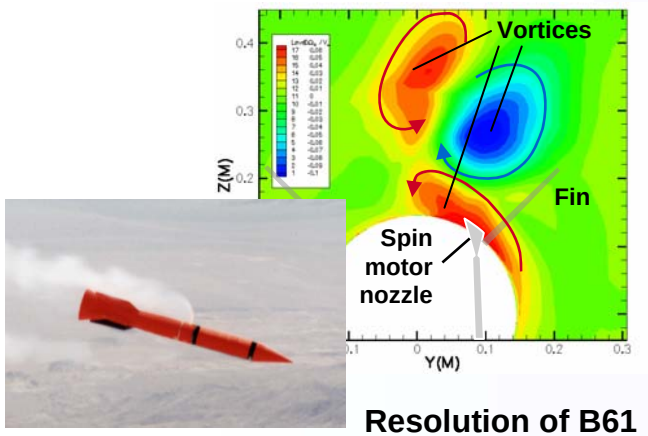
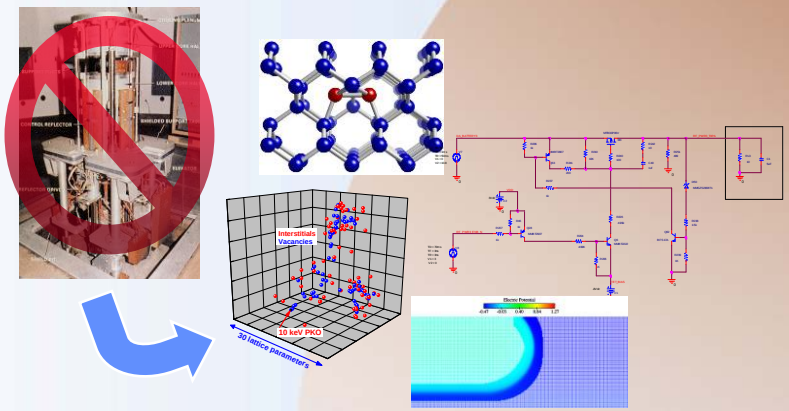
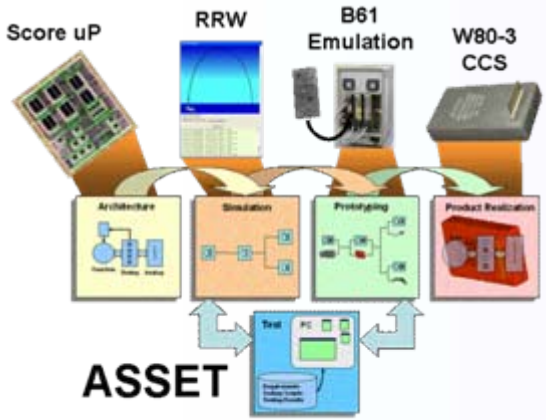
Computational Simulation Has Had a Significant Impact on Nuclear Weapon Product Engineering at Sandia



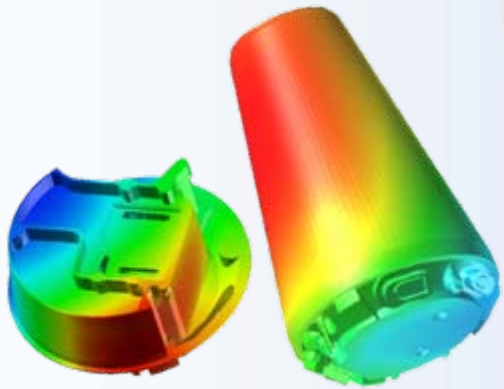
Resolution of B61 weapon issues uncovered in surveillance



Qualification Alternative to SPR (QASPR)

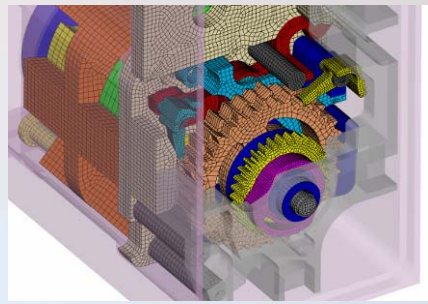


System-Level Behavioral Simulation



System Design Improvements: W76-1 System in Normal Thermal Environments

Design Issues: W76-1 Intent Strong-Link Shock-Unlock



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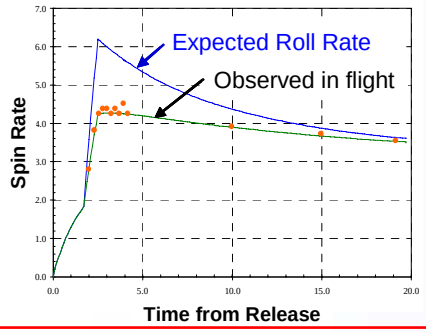
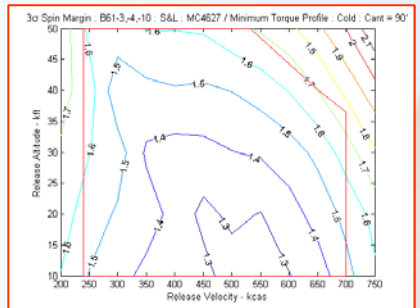
Computational Simulation Played an Important Role in Completing the Recent B61 ALTs

Interaction of jet plume w/ freestream flow results in decreased spin rates.



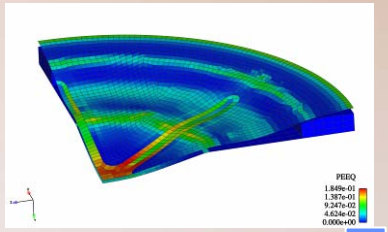
Modeling & simulation used with experimentation to improve motor design

Models were used to develop probabilistic predictions of spin rates for specification of new motor performance requirements



DSW Deliverable – Validated arming probability prediction capability

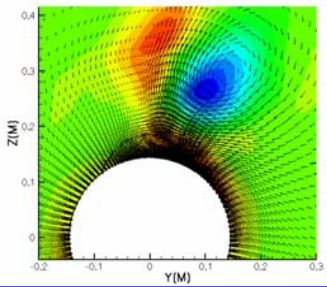
case hot spots



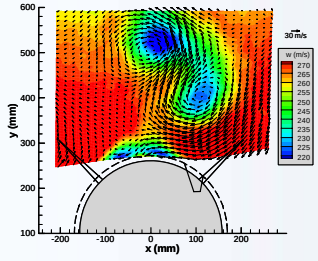
igniter disk

Motor receives 6.5 authorization and achieves FPU ahead of schedule

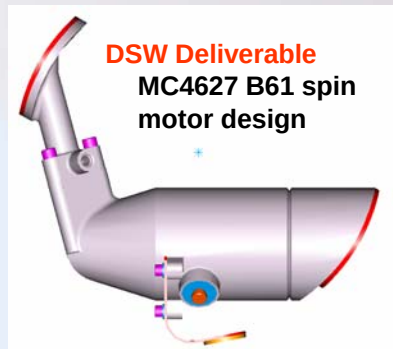
ASCI – VFI simulations



Campaign 6 – research & model validation experiments



High-fidelity computing and precision experiments used to develop understanding of interactions



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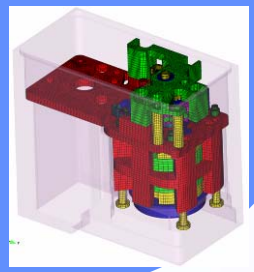
Computational and Physical Simulations Provided Probabilistic Estimates of Intent Strong-Link Performance

High-Fidelity Model (PRESTO/DYNA)

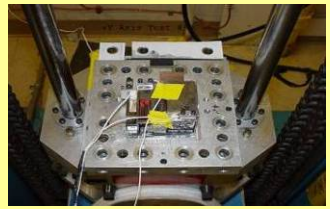
10's of Runs

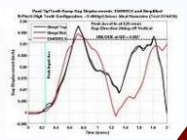


Validate

Experimental Data

100's of Runs



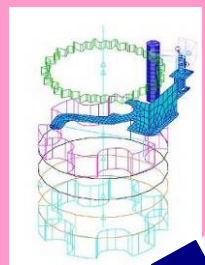


Validate

Validate

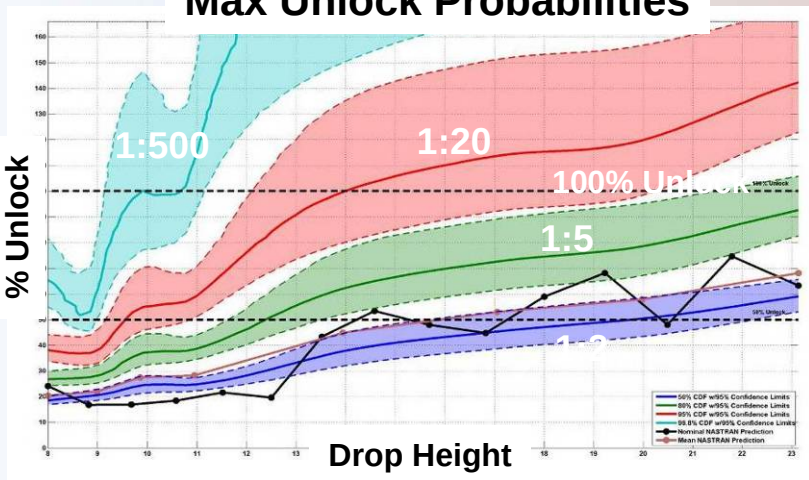
Fast Simplified Model (SALINAS/NASTRAN)

1000's of Runs



Monte Carlo Statistics

Max Unlock Probabilities



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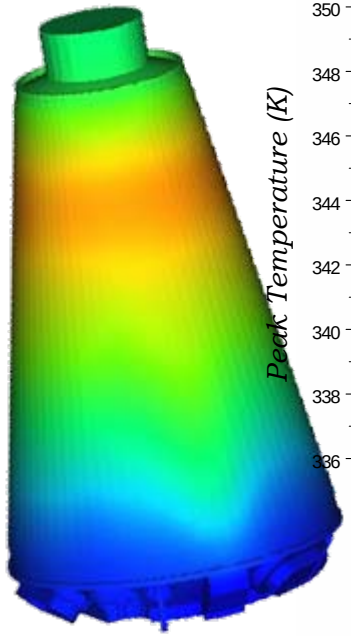
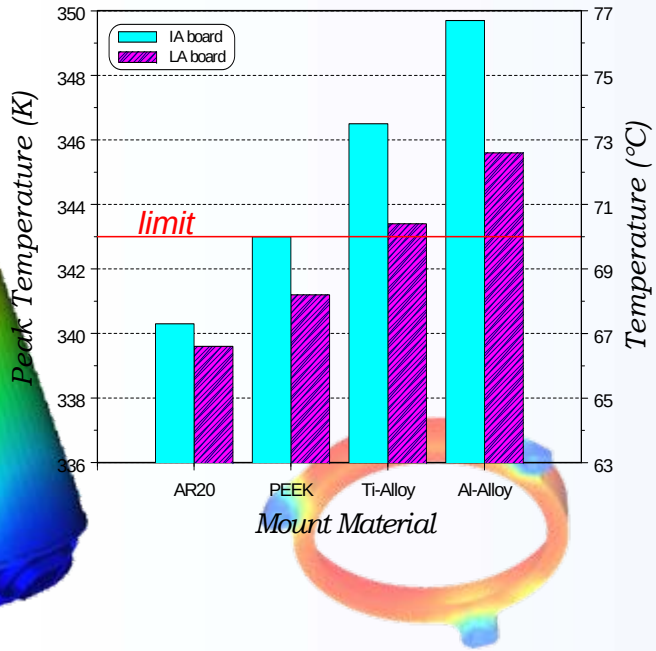
Integrated Computational and Physical Simulations for Design in Normal Thermal Environments

Support design and qualification despite limited hardware availability





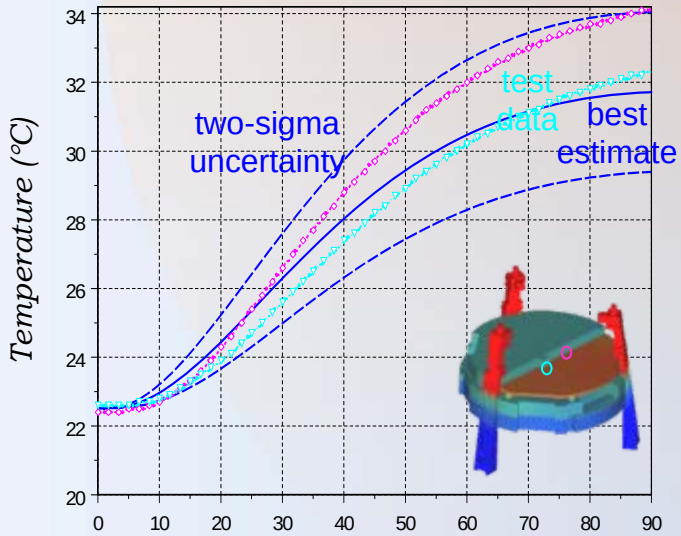
before complete hardware was available, simulations were used to identify overheating problems and to investigate potential design modifications

thermal battery tests provided model calibration data

tests using partial hardware were used to characterize the model and increased confidence in simulation results

simulation UQ studies used to develop upscreening procedure for components exceeding specifications

full-hardware qualification activity provided final model characterization and confirmatory test



successful support of normal environment design and qualification achieved

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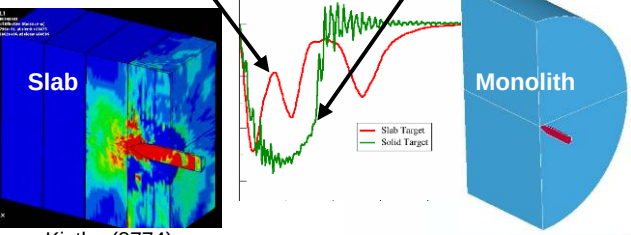
Computational Simulation was Used Extensively in Penetrator Test Design

Slab target response

Monolith target



Kistler (8774)

3

Sub-scale tests used to understand important target parameters

2

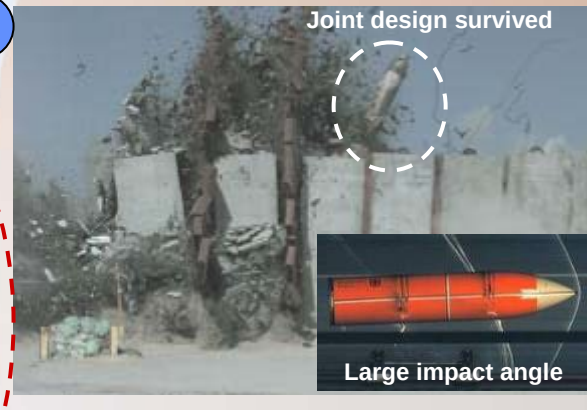
High-level DoD request for test in 4.5 months, no way to implement typical monolith target

Mod-Sim determined slab target modifications to improve response. Grout was added to make slab targets "like" monolith

4

Test 1: Unexpected impact angle, penetrator exited target, Mod-Sim quickly assessed issues

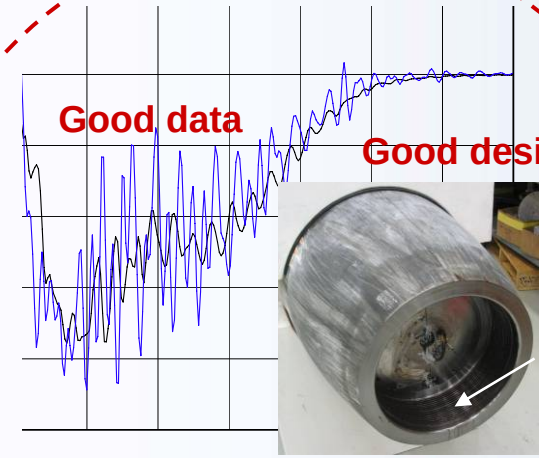
5



Mod-Sim evaluated test margins and determined adjustments to test parameters for 2nd test

6

Test 2: Adjustments improved impact angle and unit remained in target



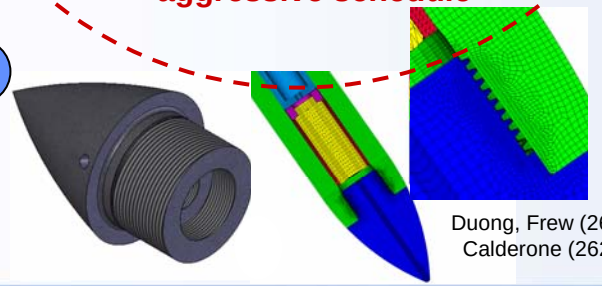
Threads in great condition post-test

Mod-Sim enabled design cycle:

- High-fidelity joint design
- Successful test setup to meet aggressive schedule

1

High-fidelity model used to design novel forward joint



Duong, Frew (2627)
Calderone (2625)

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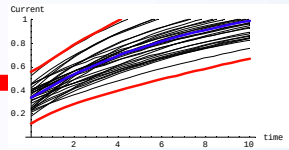
Qualification Alternatives to SPR: A Science-Based Engineering Approach for Systems Qualification

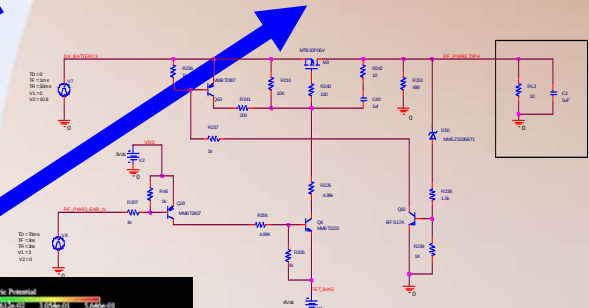
Risk-Informed Decisions

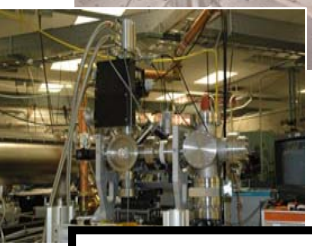


UQ, Dakota, JMP

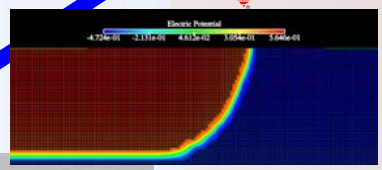
Qualification Evidence

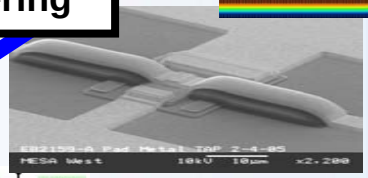
SPR, LANSCE, WSMR, IBL, HERMES, ACRR





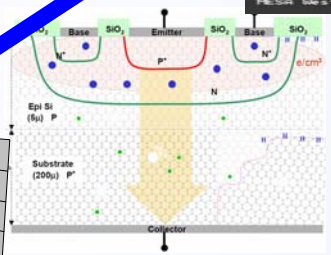
Predictive Component Engineering



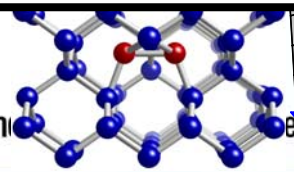


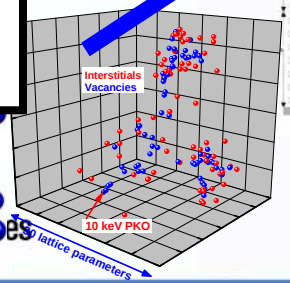
Rad Hard HBTs

Science-based predictive models and experimental validation



NUGET, Cascade, Socorro, SeqQuest, Charon, Xyce





QASPR
QUALIFICATION ALTERNATIVES TO SPR

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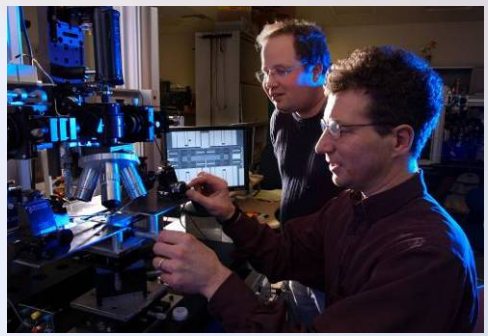
Success will Require Extensive Collaboration

- **Product Realization Teams members must span the needed capabilities & expertise:**
  - **Project management**
  - **System and component engineering**
  - **Computational simulation**
  - **Physical simulation**
  - **Manufacturing and production**
  - **Stockpile evaluation**
  - **Military Liaison**



What Am I Asking of You?

System and Component Engineering Management

- **Adopt a bias toward the use of computational simulation**
- **Understand product performance as much as possible and as early as possible in design process**
- **Quantify margins and uncertainties in product performance**
- **Enhance understanding of computational simulation technologies**
- **Adopt in-house use of simulation tools**
- **Implement engineering practices and processes to enable the above**

Computational Simulation Management

- **Place emphasis on analysis**
- **Lead application of computational simulation across all lifecycle phases**
- **Provide tools appropriate to customer needs**
- **Know the business of the product engineering customers – *what and how***
- **Develop & mature technology that enables efficient product realization**

My Expectations and Commitment

- **Computational simulation will be fully embedded in the Sandia nuclear weapon product engineering lifecycle processes – starting today**
- **Margins and uncertainties in nuclear weapon product performance will be quantified, documented, and monitored for change**
- **Engineering practices and processes will be modified to require appropriate, balanced use of computational and physical simulation**
- **Relevant organizations will partner to meet these expectations**
- ***I will personally engage as needed to ensure computational simulation is fully embedded in our nuclear weapon product engineering activities***

Our Challenge

We have an opportunity to define our future with regard to the use of computational simulation in nuclear weapon product engineering at Sandia

- **We have the technologies, facilities, and capabilities to be successful**
- **We must improve the integration of our product engineering and computational simulation capabilities**

All that remains is for us to work together….

I commit to removing the impediments and creating the environment needed for us to succeed!

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