NEAC Review: NEAMS

Nuclear Energy Advanced Modeling & Simulation

Summary of Subcommittee Report

December 6, 2012

Raymond J. Juzaitis, Ph.D.
Chair, NEAMS Review Subcommittee

Subcommittee Chartered in Fall 2011

- Independently evaluate NEAMS program
- Provide recommendation to Assistant Secretary for Nuclear Energy
- Review full scope of NEAMS activities
  - Basic strategy
  - Management execution
  - Code development portfolio
  - Crosscutting and enabling scope of work:
    - Verification and Validation
    - Fundamental methods and models

Ad-Hoc Subcommittee of NEAC was invited to conduct the Review

Member	Affiliation
Ahearn, John	Sigma Xi
Christensen, Dana	National Renewable Energy Laboratory
Juzaitis, Raymond (Chair)	National Security Technologies, LLC
Kusnezov, Dimitri	NNSA
Little, Robert	Los Alamos National Laboratory
Matzie, Regis	Westinghouse (retired)
Peery, James	Sandia National Laboratory
Ray, Sumit	Westinghouse
Rosner, Robert	University of Chicago / ANL
Sattelberger, Al	Argonne National Laboratory
Wirth, Brian	University of Tennessee

Two Subcommittee Meetings Were Held

- Meeting #1 (December 14, 2011)
  - Vision
  - Strategy
  - Overall management structure
- Meeting #2 (May 22-23, 2012)
  - Technical approach
  - Technical direction

Observations following first meeting

- Expansive vision in the mode of NNSA's ASC or DOE/SCI's ASCR programs
  - Predictive simulation to transform the civilian nuclear energy enterprise
- Lack of balance between vision and resources
- Duplication between NEAMS and CASL
- Federal management and reporting complexity was too pervasive given $23M (and declining)
- User community overly representative of National Labs, without end-user requirements

Major changes occurred between first and second subcommittee sessions

- NEAMS resources slashed
  - $26M (FY10) to $10M (FY13, projected)
- Downsized from 4 Integrated Performance and Safety Codes (IPSC) and 4 cross-cutting "Common Methods and Tools"
  - Two product lines now supported (fuels & reactors)
  - One adaptive set of simulation tools ("Fermi Toolkit")
- Management structure simplified

"Fermi Toolkit" signifies a shift in computing paradigm

- Modularity and flexibility achieved through modern computing techniques and tools
- Configurable set of "tools" to address a wide scope of research, design, analysis needs
- First version to appear in FY13
  - 5 years to develop full set of capabilities
- Complementary experimental efforts conceivably useful for validation are ***not covered*** by NEAMS resources

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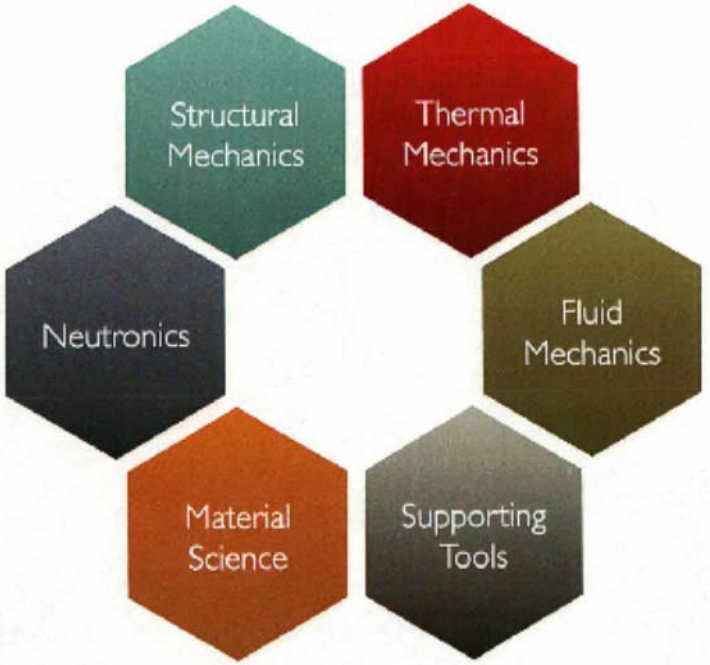
THE FERMI TOOLKIT

- Integrates modular toolsets for representation of key physical phenomena
- Provides foundation for development many customized user environments - the equivalent of what we might have previously called codes
- Serves as a repository for collection and transfer of the knowledge and expertise of the DOE complex
- Establishes a framework for collaborative innovation and a pathway for delivery of real products to real end users
- Near term products pave way for future Research & Development



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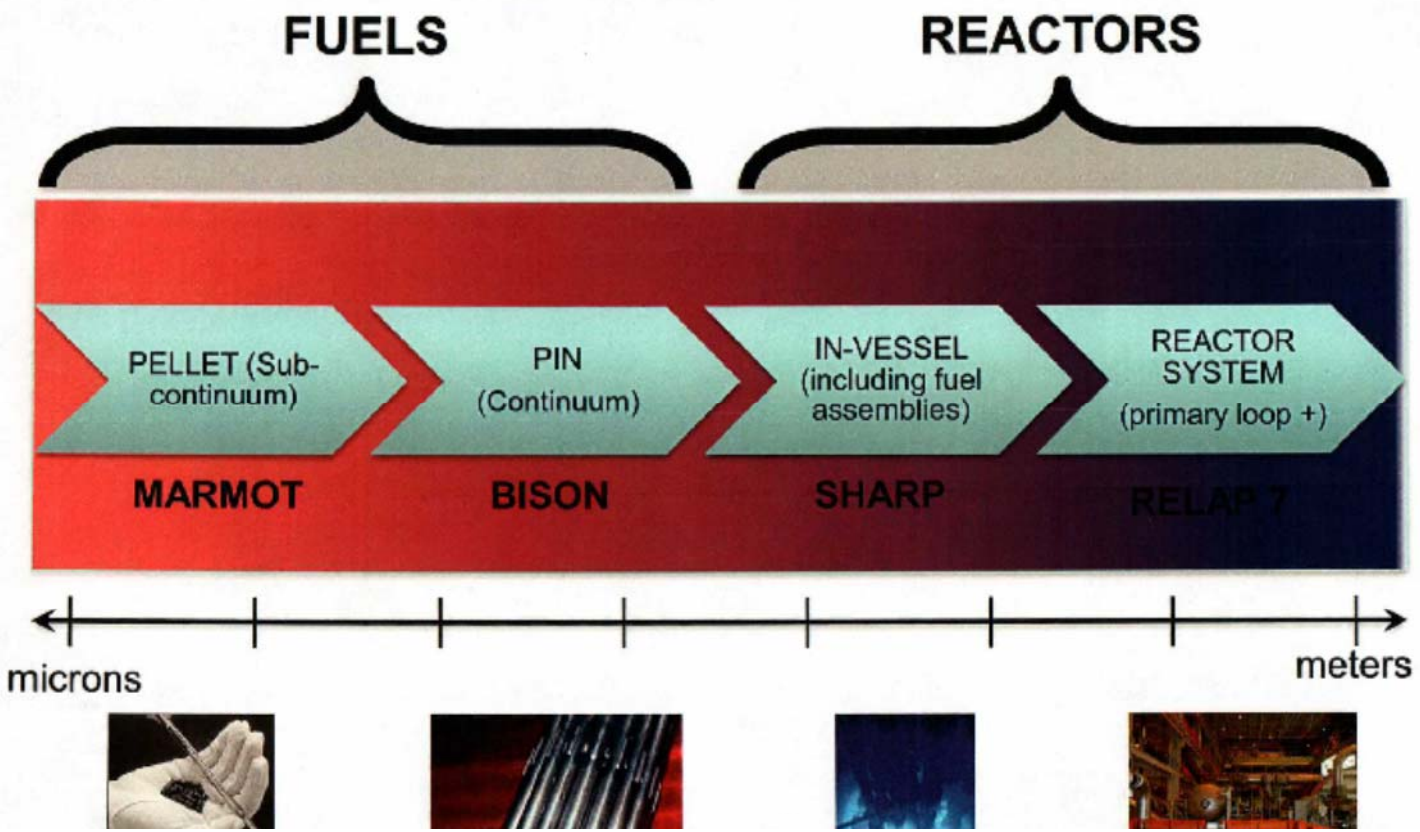
The Fermi Toolkit couples phenomena where appropriate



Fuels Product Line

- Marmot
  - Meso-scale microstructure evolution code
  - Focus on nuclear fuel design and analysis
  - Enables prediction of microstructure evolution under irradiation
- Bison
  - Engineering-scale fuel performance tool
  - Interfaces with reactor codes at fuel assembly scale
  - Fully-coupled thermo-mechanics and species diffusion in 2D or 3D
  - Enables prediction of fuel-pin failure

Reactor Product Line

- SHARP
  - Multi-physics, multi-scale simulation to enable predictive modeling of a full reactor core (3D)
  - Hierarchical bridging from DNS, through LES and RANS-based CFD, to lumped-parameter system models
  - Nek5000 fluids module is spectral element code
- RELAP7
  - Modern 0D/1D reactor system/safety analysis code
  - Evolutionary extension of RELAP5
  - Projected to meet all NQA-1 requirements
  - BWR transients associated with full-station blackouts

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Our product will be trustworthy

- **An un-validated product is worthless *or worse***
- **We must**

- Verify algorithms against analytical solutions
- Validate using data standards (provided mostly by users)
- Quantify uncertainties in regimes of applicability
- Produce standards of usage
- Assure software quality by employing established standards

These must be achieved *before* public release

Subcommittee Observations

- NEAMS funding pales in comparison to other national modeling and simulation programs
- “Fermi Toolkit” approach is sound
  - Flexible, collaborative, affordable environment
  - Multi-physics, multi-scale approach is aligned with objectives of predictive capability
- Applaud systematic leveraging of existing work and previous R&D investments
- Ubiquitous references to Verification and Validation not matched by strong commitment from NE R&D programs to provide aligned experimental program (“Achilles Heel”)

Observations (contd)

- More tractable management structure
  - Role of National Technical Director confusing
  - CASL has exemplary model for empowering technical leadership
- Reactor effort more coordinated than fuels effort
  - Fuels effort needs more application focus and prioritization
- Transition from RELAP5 to RELAP7 will require much greater socialization with NRC and industrial stakeholder community

Subcommittee Recommendations

- NEAMS requires a stronger and more compelling requirements definition process
- Program should adopt a more formal and rigorous requirements "flow-down" process to coherently integrate program around "milestones" that meet user predictive capability needs
- Program MUST integrate computational efforts with requisite experimental activities to support validation
  - *Milestones should demand successful simultaneous execution of both computational and experimental efforts*
- Fuels effort should inform "accident-tolerant fuels" development , post-BRC long-term storage effort
- NEAMS needs to articulate a compelling "business case" to its stakeholder community