LA-UR-15-21368
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Title:	MaRIE 1.0: A briefing to Katherine Richardson-McDaniel, Staff Member for U. S. Senator Martin Heinrich (D-NM)
Author(s):	Barnes, Cris William
Intended for:	Briefing to Congressional staff member.
Issued:	2015-02-24

MaRIE 1.0:

A briefing to Katherine Richardson-McDaniel, Staff Member for U. S. Senator Martin Heinrich (D-NM)

Cris W. Barnes

Champion for Matter-Radiation Interactions in Extremes

February 18, 2015

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ABSTRACT

At the request of Katherine Richardson-McDaniel, Staff Member to U.S. Senator Martin Heinrich (D-NM), a high-level briefing was requested about MaRIE 1.0, the Matter-Radiation Interactions in Extremes effort at Los Alamos National Laboratory. What it would be, the mission need motivation, the scientific challenge, and the current favorable impact on both programs and people are shown in viewgraph form.

MaRIE is the experimental facility for the time-dependent control of dynamic material performance

The Mission Need

Develop flexible and low-cost product-based solutions to materials problems in the stockpile through accelerated qualification, certification, and assessment.

The Challenge

Interfaces, defects, and microstructure between atomic scale and engineering continuum determine time-dependent material properties – the mesoscale.

What It Is: The Capability Gap

MaRIE fills the gap with:

- 42-keV XFEL for coherent, brilliant, repetitive x-rays; and
- Multiple simultaneous probes (x-ray, proton, electron, optical); and
- Close linkage to synthesis, fabrication and characterization facility; and
- Full integration with advanced theory, modeling, and computing.

How It's Done

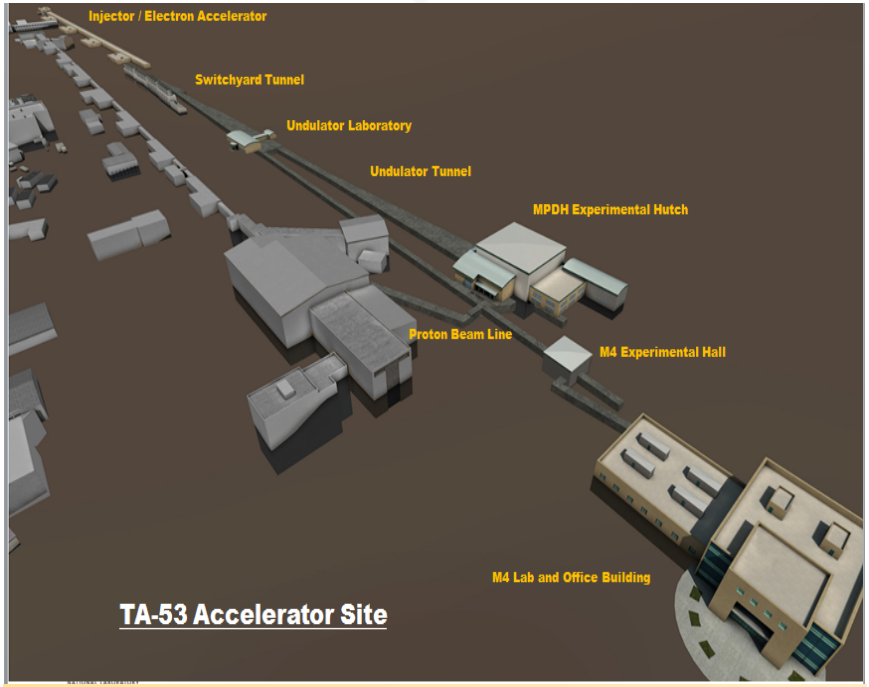
After time-dependent control of process, structure, and properties during synthesis of materials at the mesoscale, MaRIE will subject them to extreme environments and use both imaging and diffractive scattering to connect to the product performance.

MaRIE responds to the NNSA Tri-lab Facility Roadmap Gap of

"predict and control from materials and devices to manufacturing processes"

Production → Button → Boom → Disposition

- MaRIE will provide the world's first very-hard (42-keV) **XFEL** with GHz (few pulses) repetition;
- A **Making, Measuring, and Modeling Materials (M4) Facility** for materials synthesis and characterization with high-performance computational co-design focused on the mesoscale; and
- A **Multi-Probe Diagnostic Hall (MPDH)** coupling hard, coherent, brilliant x-ray photons with 12-GeV electron and 0.8-GeV proton radiographic tools in time-dependent extremes.

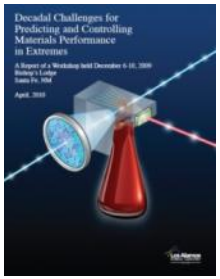


MaRIE is a cost-effective and logical extension of the current capabilities of LANSCE at LANL.

With the support and encouragement of senior leadership at NNSA/DOE, LANL has committed to submitting a CD-0 request by Summer 2015

- **A new direction for the nuclear enterprise**
- **A "new start" in the 2020's**

Developing the Science Case

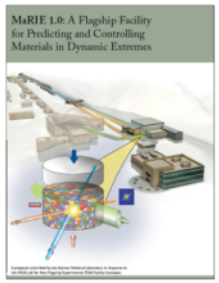


(2009)

Facility Definition

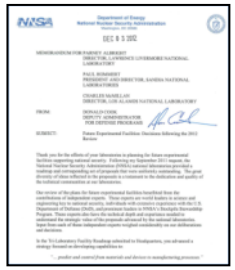
(2010)

Pre-conceptual Proposal



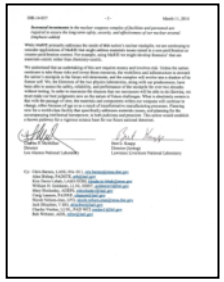
(2012)

"Move to CD-0"



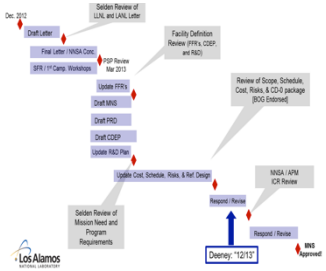
(12/2012)

Setting the stage for Mission Need



(2014)

Path to CD-0



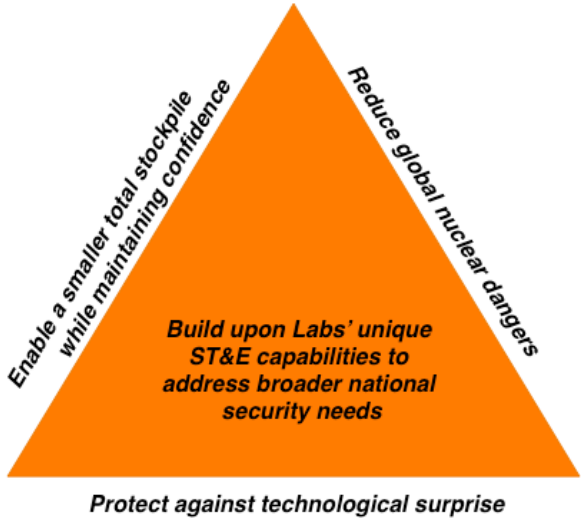
(2015)

At the inception of the Stockpile Stewardship Program, stockpile performance was the primary mission driver; post-2020 mission drivers are more diverse

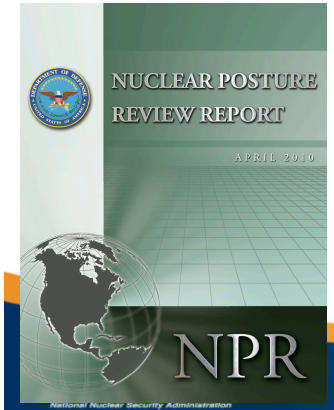
- **Stewardship Past: *Underwriting the STS***
  - Emphasis on performance and reliability: The STS
  - Dominant concern: *hubris*

Button → Boom

We cannot afford the same.



- **Stewardship Future: *Underwriting the life cycle***
  - Broadened emphasis: From "Ore to Disposition" and others' stockpiles
  - Dominant concern: *paralysis.* Preventing loss of confidence where we should have it



Production → Button → Boom → Disposition

To afford the mission, the way we do it must change!

MaRIE provides the materials science that supports other thrusts:

Pu Strategy; Sub-critical experiments; Advanced Manufacturing; Exascale for Materials …

The Mission Need:

Sustain a safe, secure, and effective nuclear arsenal

Through accelerated qualification, certification, and assessment.

Guarding against nuclear technology surprise

Dynamic Materials Performance
First Campaigns

- Multiphase High Explosive Evolution
- Dynamic Performance of Plutonium and Surrogate Metal Alloys
- Turbulent Material Mixing in Variable Density Flows

Certifiable, flexible and low-cost product-based solutions to materials problems

Process-Aware Manufacturing
First Campaigns

- Old Materials: Aging
- New Materials: Controlled Functionality
- New Processes: Advanced and Additive Manufacturing

Verifying treaties, combating nuclear terrorism and proliferation

More efficient and less costly enterprise underpinned by investments in science and infrastructure.

Strengthen the ST&E base

Energize the people of the nuclear enterprise

Drawn from the 2015 NNSA SSMP

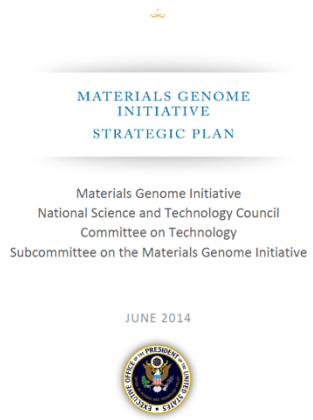
LANL-led efforts with the Scientific Community ~2006-2012 defined the Grand Challenges

Requirements:
Sub-μm space resolution
100's – 1000's-μm samples
Sub-ns time resolution,
~30 frames in
1−10-μs duration

meso2012.com

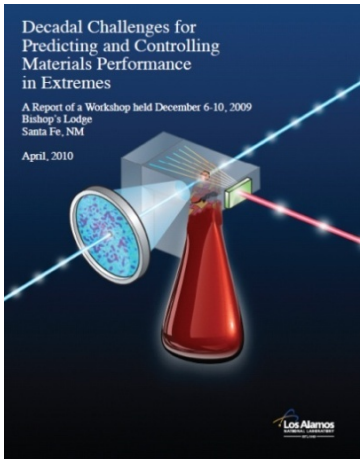
science.energy.gov

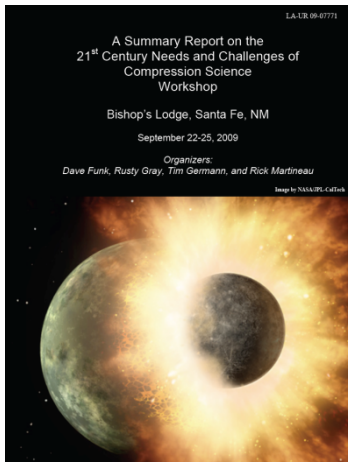
Materials Genome



Advanced Manufacturing

Whitehouse.gov

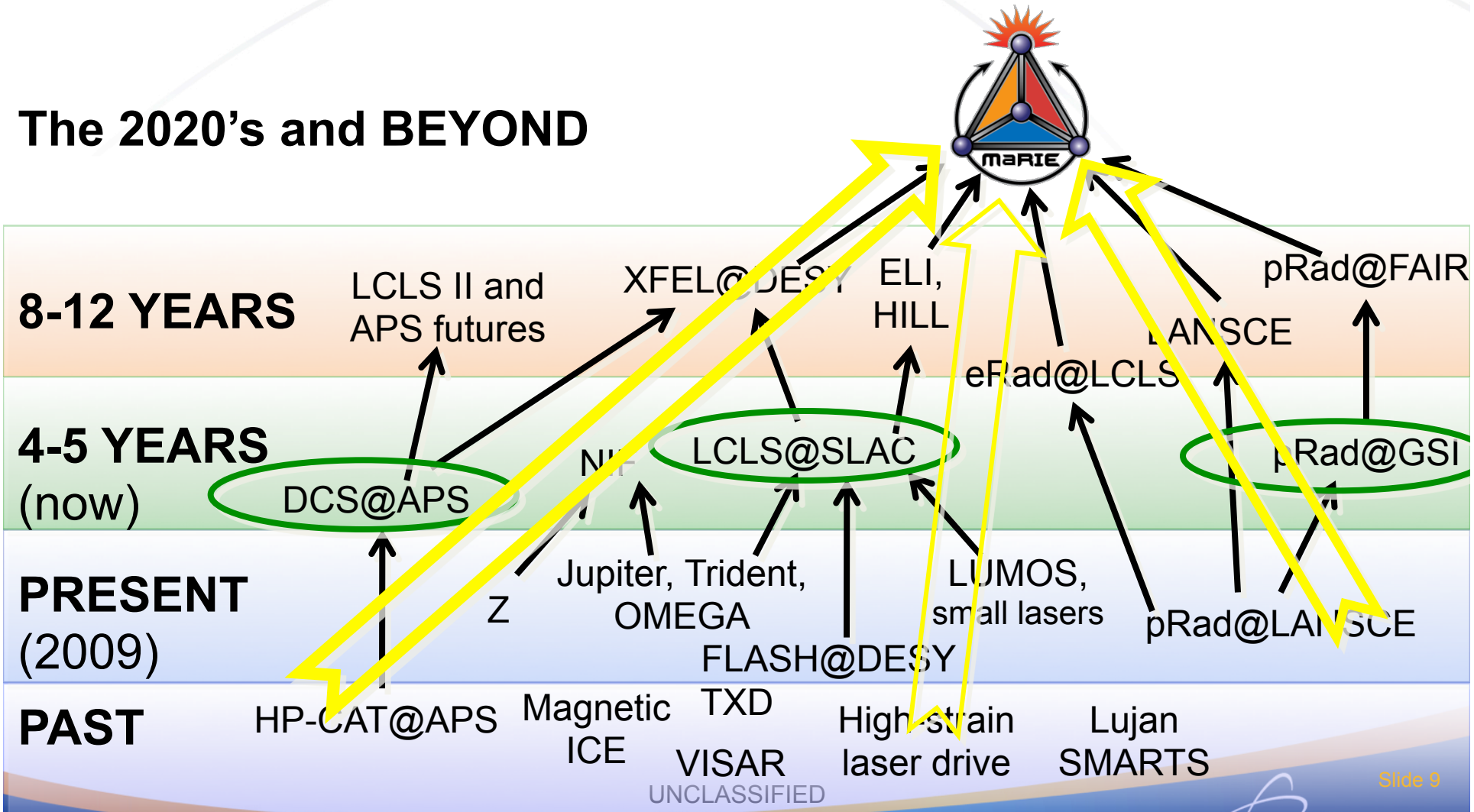




MaRIE is the experimental facility for the mesoscale, positioning LANL as world leader in applications of materials science.

We are doing science and technology on the Roadmap to MaRIE today

The 2020's and BEYOND



MaRIE 1.0 science and mission is already attracting the best and the brightest across broad disciplines

Ricardo Mejia Alvarez
P

Amy Clarke
MST

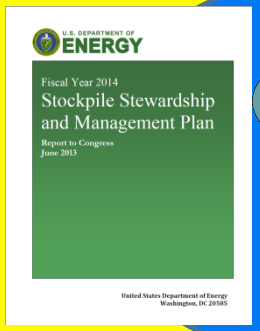
Sky Sjue
P

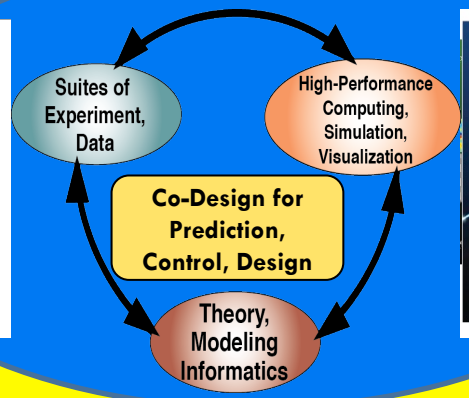
Saryu Fensin
MST

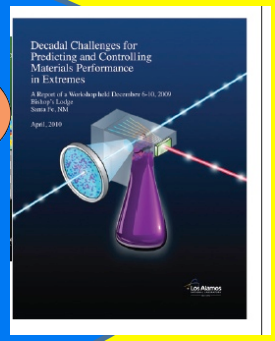
Cindy Bolme
WX

Garry Maskaly
XTD

Kyle Ramos
WX







Marianne Francois
CCS

Abigail Hunter
XCP

Nikolai Yampolsky
AOT

Richard Sandberg
MPA

Quinn Marksteiner
AOT

John Barber
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Irene Beyerlein
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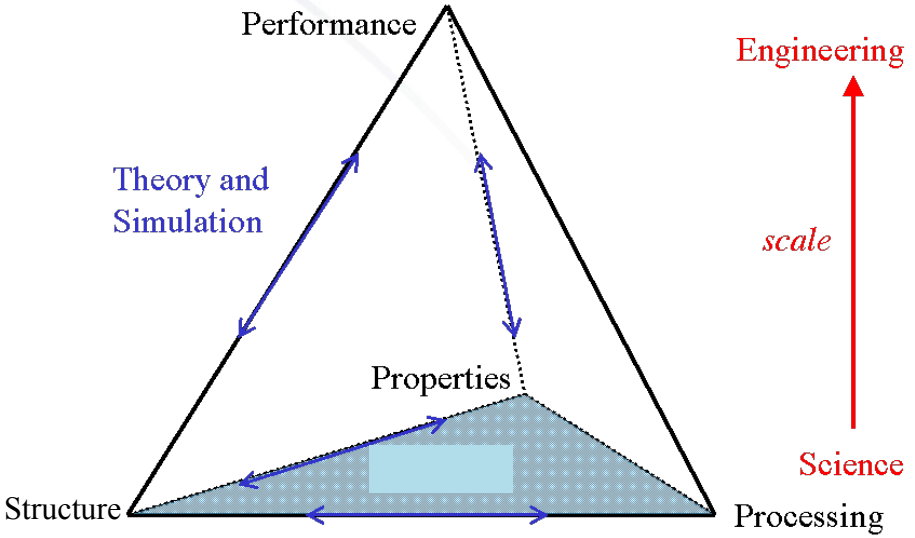
Backups and connection to Additive Manufacturing and Exascale

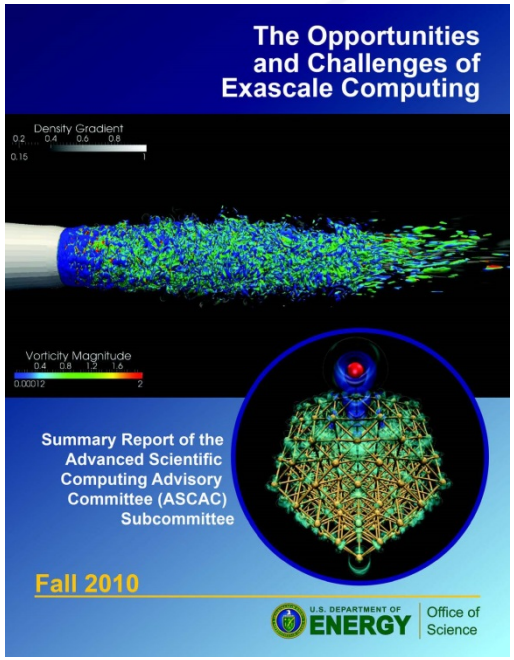
MaRIE 1.0 is about *both* time-dependent control of making materials, and measurements of their time-dependent performance

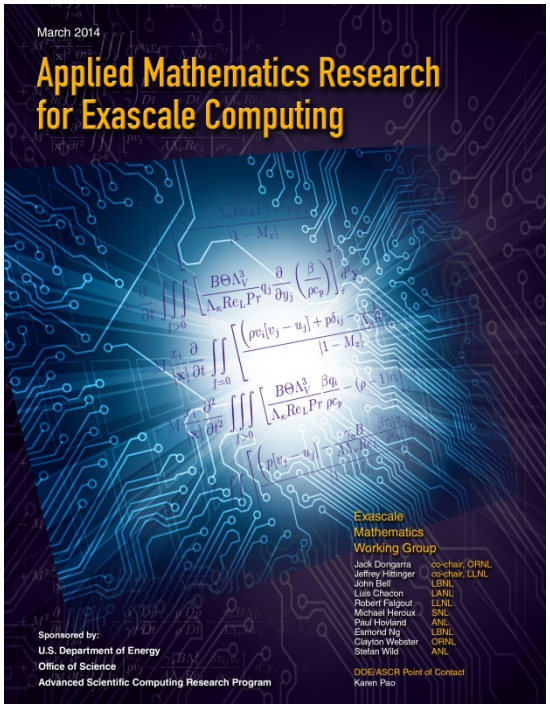
- Materials Design is the integration of **structure** and **processing** to achieve a desired **property** of a material, all of which determines the **performance** of an engineering system with the intent to
  - (A) develop new materials and properties,
  - (B) select functions of materials for applications, or
  - (C) optimize performance of a given material.

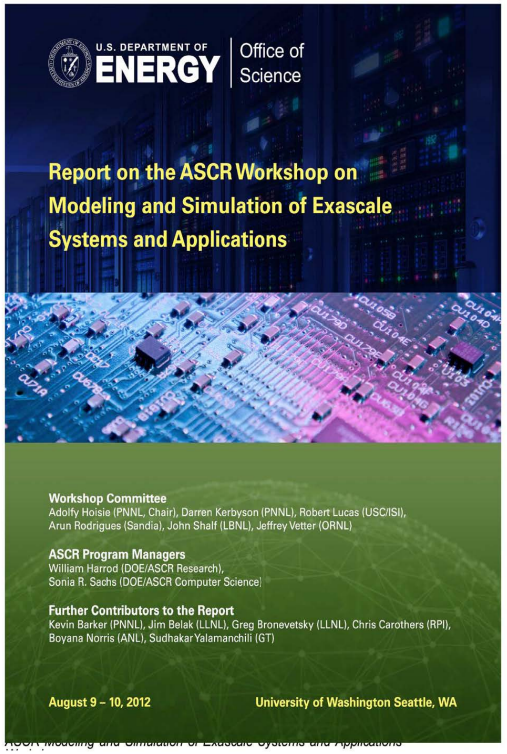


Vision: *MaRIE provides* ***process-aware manufacturing R&D capability*** *that integrates in-situ diagnostics with real-time adaptive modeling for concurrent feed-back control at the mesoscale for "born-qualified" materials.*

MaRIE will be operating in an environment of exascale computing and future codes







Experimental Facilities are needed to Discover mechanisms, Validate and Calibrate sub-grid models