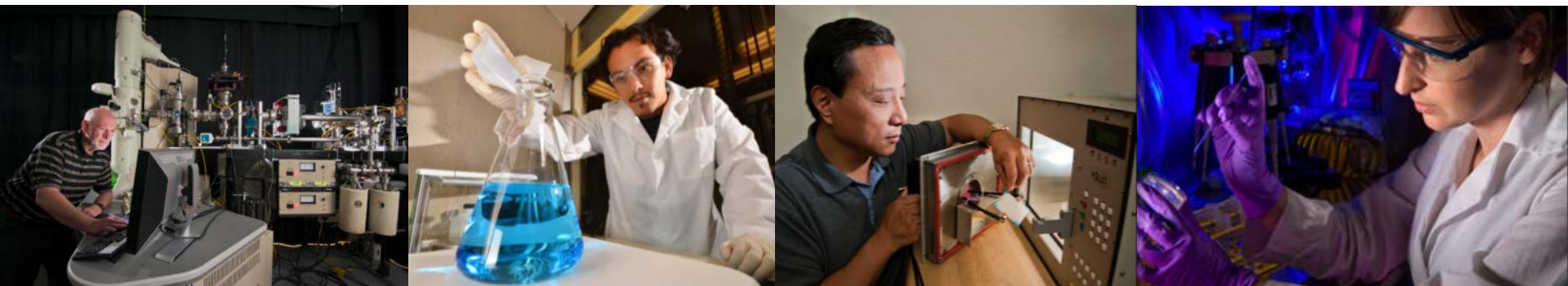


Exceptional service in the national interest



Materials Science RF Strategy and Scenario Planning Update

J. Charles Barbour

Director, Physical, Chemical and Nano Sciences Center

with Carol Adkins, Malin Young, and Anthony Medina

April 8, 2014

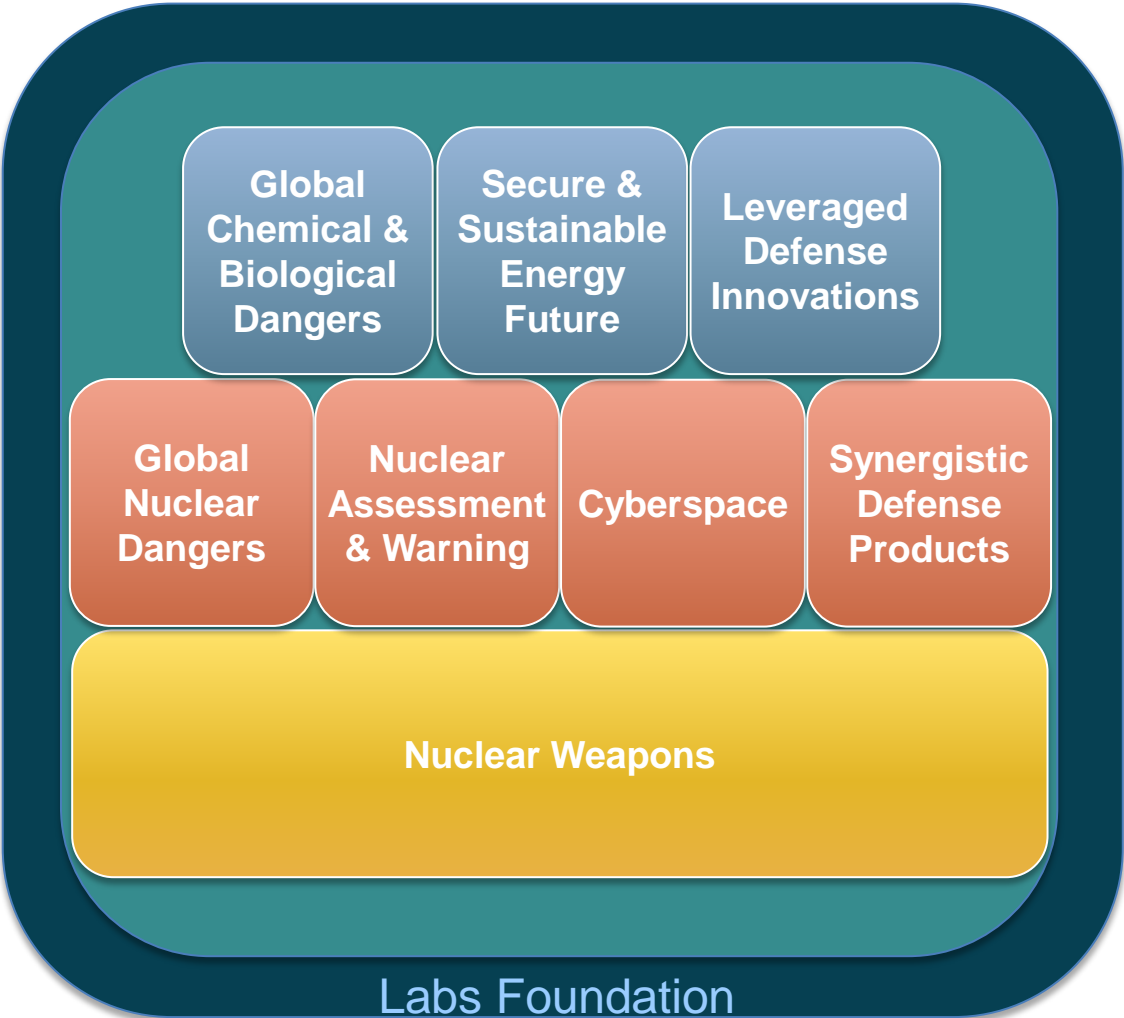


Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Overview

- **RF alignment with Sandia's corporate strategy**
- **Scenario planning to sharpen RF strategy, examine robustness, and align with Missions and Research Challenges**
- **RF strategy communication**

Sandia Missions Baked-Up by Labs Foundations



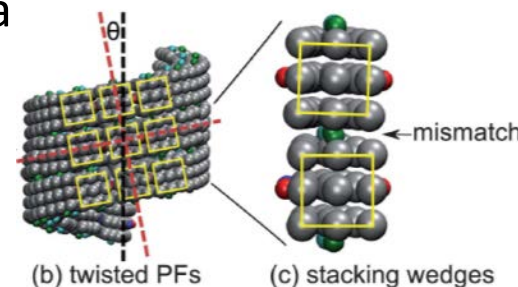
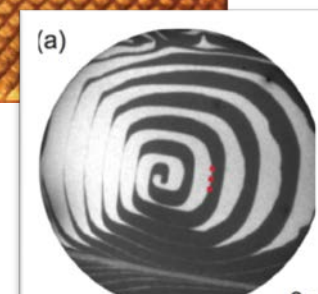
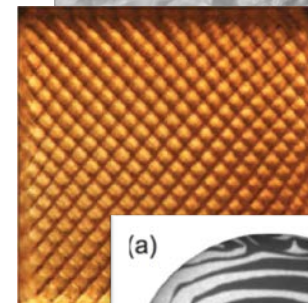
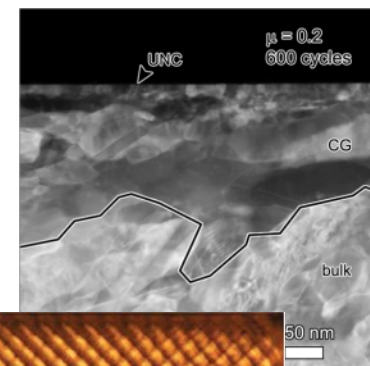
Materials Science RF Strategic Intent

MSRF excels in innovative fundamental materials science research – developing and integrating the theoretical insights, computational simulation tools and deliberate experiments that provide foundational, predictive understanding of the performance of Sandia’s current and future mission-critical materials in order to provide the solid technical basis for Sandia’s engineering decisions and enabling future mission work.

This RF supports multiple Mission Areas, leads 2 Research Challenges (RCs), and supports 5 other RCs.

Strategic Plan: Five MSRF Thrusts

1. **Predicting Performance and Reliability** of materials and devices over extended time periods and demanding environments.
2. **Control of Energy, Mass, and Charge Transfer** to enhance the function and efficiency of materials for crosscutting mission needs.
3. **Developing new materials, in particular Next Generation Materials for Electronics and Optoelectronics**, to deepen our understanding of materials characteristics that may be exploited or mitigated to support mission need.
4. **Computational Materials Synthesis and Processing** to provide a deeper understanding of the physical principles and putative paradigms that govern growth, synthesis, a processing.
5. **Novel Characterization and Diagnostic Tools and Techniques** for evaluating mechanisms and supporting computational materials science.



Strategy & Scenario Planning

- July 15-16, 2013: Directors, Fellows, Sr. Managers, and Sr. Scientists from 1100, 1800, 2500, 8000, 6100, and 6900 (30+ managers in all) evaluated strategic thrusts relative to mission:
 - Reviewed Strategy
 - Relevance to mission
 - Differentiating Sandia capabilities – “Branding” exercise
 - Scenario Planning Exercise
 - How robust is strategy to different futures
 - Identified areas where strategy is silent
 - Potential partnering opportunities
 - Customer engagement and big challenges (MAs and RCs)

Strategy – Robustness to scenarios

Boom

- Economy heats up
- Industry hiring like gangbusters
- LDRD program strong & stays the same
- Nation exporting energy

1. “Science/Engineering-Lab”

- Energy and science programs are strong (but we’re not an energy/science lab)
- We have trouble hiring
- Core mission still exists, but we’re focused on supporting the remaining/diminishing stockpile
- We are an advisor, not developer, on satellite systems
- Sandia looks “Battelle-like”
- Two-valley model maintained, but Sandia loses DA-role for some of it’s core products (e.g., AF&F, GTS)
- IC customer at Sandia is diminished

“World Peace”

- Drive to zero for nukes is program du jour
- NNSA at risk, there’s talk of moving us to DoD
- Programs reprioritized between LLNL, SNL, LANL
- All production consolidated at KCP
- DOE energy programs up, Office of Science strong
- No new satellite systems

Economy

2. It’s a Material World



- Opportunities exist for new defense, IC customer development
- Materials call upon heavily by current NW, defense, IC customers
- We have trouble hiring, trouble retaining
- LDRD \$ abounds, and we control the direction
- Opportunity exists for new materials/technology insertion across customers
- Labs chooses to de-emphasize energy security
- NW work has a strong engineering focus

It’s a Dangerous World

- NNSA strong, three weapons labs healthy
- Need for satellite/remote sensing grows
- IC (intel community) strong, Defense strong
- DOE energy programs down, Office of science flat

National Security Threat

3. Researchers Work for Food

- Sandia chooses to engage in energy security programs for reasons of national security
- Materials science has no direct control of LDRD \$
- People are knocking on our door for jobs
- Environmental data from satellites/remote sensing creates opportunity
- NW work has a strong engineering focus

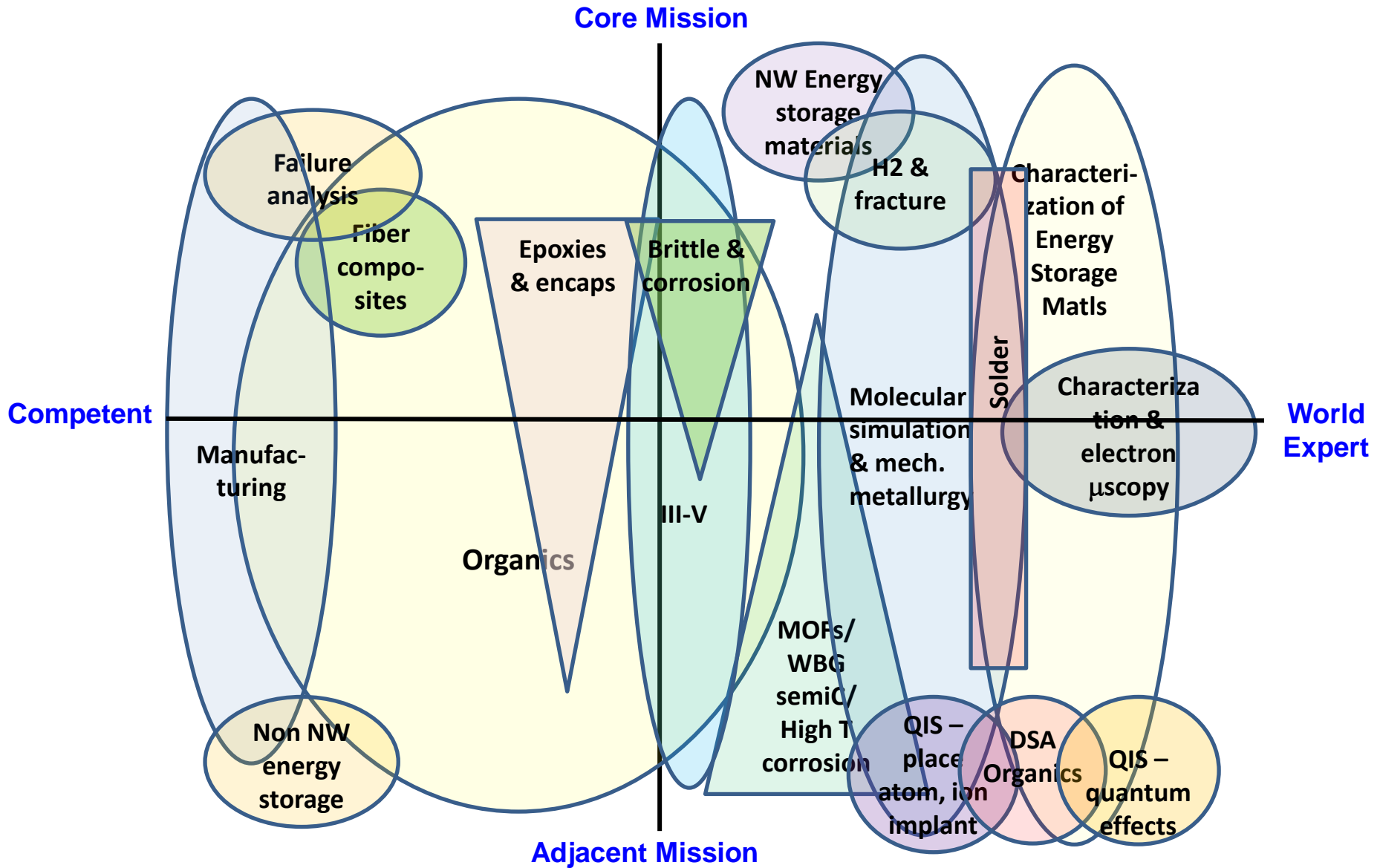
4. Reinventing Ourselves

- Energy and science programs are strong (but we’re not an energy/science lab)
- Exec leadership team recognizes Labs must change
- Graduates/experts are available to hire
- Sandia chooses to engage in energy security
- Materials must focus in order to leverage energy and science work to grow niche expertise

Bust

- Economy down
- Sequestration going strong
- Customers struggling
- Environmental concerns halted the shale gas furor
- LDRD program down – capped at 4%, LDRD restructured in favor of Mission Areas/Research Challenges

Mission Space vs. Differentiation



Summary/Conclusions from Exercise

- **The five thrusts are robust to alternate futures, but**
- Need to push hard on predictive understanding now to be ready for the future need -- not as much in LDRDs now as we would like
- Need deeper look for how to include trust/cyber in strategy
- Add IP strategy to RF strategy
- Workforce needs to be more agile to funding streams
 - **Staff Development**
 - **Increase staff knowledge of customer needs**
 - **Management engagement with Mission Area strategies**
- Lead development of Research Challenges that mesh with our strategy and the Mission Area needs
 - **Engineering of Materials Reliability (predictive performance & reliability)**
 - **Power on Demand (energy storage materials, wide bandgap semiconductors, ...)**

FY13-14 Strategy Implementation Goals

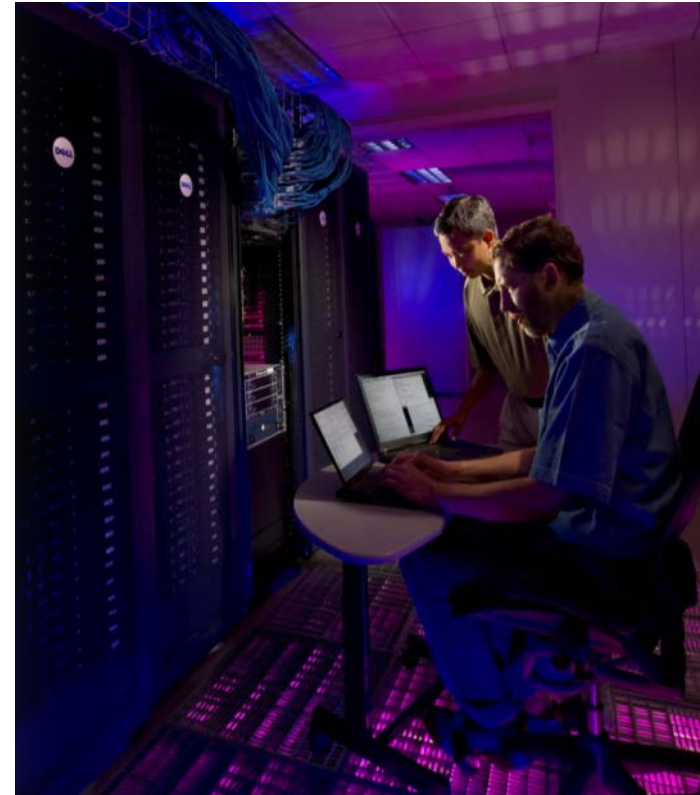
Action	Description	Status
1	Hold a workshop on the safety and reliability of electrochemical energy storage systems and explore options for the Sandia energy storage strategy	Done
2	Hold a predictive brittle materials performance workshop – invite experts – to identify state-of-the-art, gaps, and alignment with Sandia’s capabilities.	Done
3	Develop a plan with the Biosciences RF for jointly supported work – e.g., bio-enabled materials, materials enabled bio-functionality, etc.	Ongoing
4	Develop a plan with the ESRF for jointly supported work in the area of time- and length- scale integration. Select a specific topic area that will serve as a model for other applications.	Done
5	Work with DSA on program development (ongoing) by getting a seat at the table early.	Done
6	Serve as Sandia point on Hub calls where materials can lead the response (e.g., energy storage, critical materials).	Done
7	Hold a national-level workshop on wide bandgap semiconductor materials (already planned). Supports our intent to be a key player in a potential call from DOE/EERE for wide band gap materials.	Done
8	Brainstorm and review via gap analysis, the best alignment of Sandia’s capabilities and mission needs in the area of computationally-designed materials and processing. Don’t lose the emphasis on processing: welding, joining, soldering, etc.	Ongoing

Goals

Action	Description
1	Competitor/partner landscape and external view (need to figure out how we'll do this!)
2	Update the strategy based on scenario planning
3	"Customer intimacy" pilot – leveraging our understanding of the customer
4	Hold next materials science all-manager meeting in early 2014
5	"Boldness" – strategy for increasing our "boldness." (NOTE: as this pertains to SC, ID our early career staff and work with them to increase visibility, help them with proposal) How can we mentor "boldness", learn it?
6	MS LDRD – Review how we structure the call and encourage "boldness" of thought
7	Increase impact of LDRD – Review our publication landscape (cross-correlate materials science high impact journals with international high impact journals); What can we learn from those LDRDs that are high producers?

Sandia's Research Challenges (RCs)

- *Engineering of Materials Reliability*
- *Power on Demand*
- *Trusted Systems & Communications*
- *First to High-Yield Fusion*
- *Detection at the Limit*
- *Science & Engineering of Quantum Information Systems*
- *Revolutionary Approaches to the Stockpile*
- *Beyond Moore Computing*
- *Data Science*
- *Cyber Resiliency*
- *Resiliency in Complex Systems*
- *Biosystems Analysis and Engineering*



■ **Predicting Performance and Reliability:**

- Predicting the failure of brittle materials, predicting the performance and aging of materials in their service environments, and promoting the science of “trusted” materials and methods to assess materials risk and modification or self-healing materials — polymers, metals and composites — that support trusted design.
- [Engineering of Material Reliability, Detection at the Limit, Trusted Systems, First to High-Yield Fusion, Revolutionary Stockpile RCs](#)

■ **Control of Energy, Mass, and Charge Transfer:**

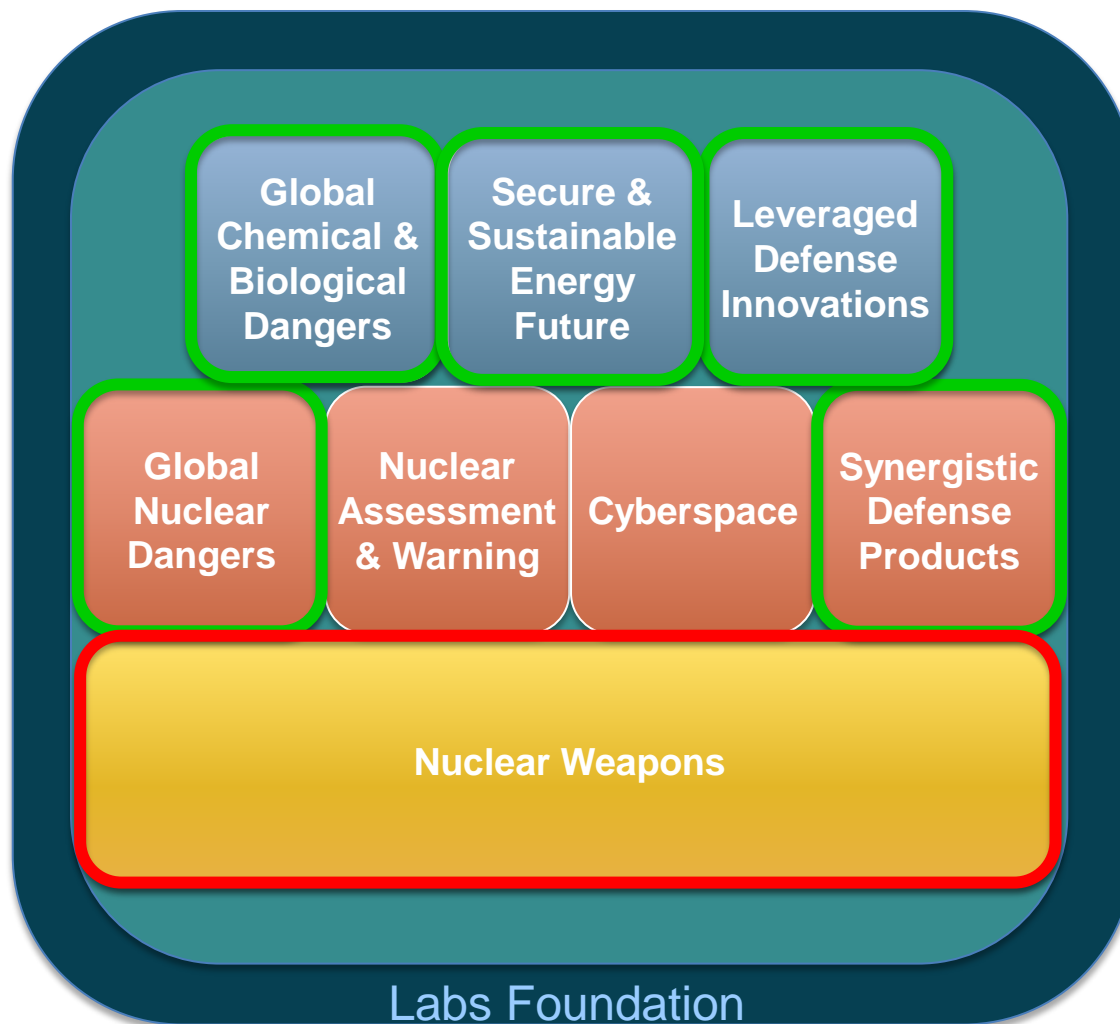
- Electrochemical processes (batteries, electrochemical syntheses, corrosion), microscale thermal transport, transport and utilization of optical energy, and diffusive and chemically reacting mass transfer
- [Power on Demand RC](#)

■ **New materials, Next Generation Electronics Optoelectronics:**

- Low dimensional semiconductors and MOF-based nanostructures, ultrawide bandgap semiconductors and accompanying gate insulating materials for enhanced performance in power applications, narrow bandgap materials for sensing, materials for exploiting quantum phenomena and nanostructured materials that enhance sensitivity and selectivity in chemical, biological, and radiological detection.
- [Power on Demand, Detection at the Limit, Science & Engineering of Quantum Information Systems RCs](#)

- **Computational Materials Synthesis and Processing:**
 - Fundamental processing-microstructure-property-performance relationships in metal additive manufacturing processes, and optimization of properties of advanced materials using computational theory and models, as well as careful experimental validation.
 - [Engineering of Materials Reliability RC](#)
- **Novel Characterization and Diagnostic Tools and Techniques :**
 - *In-situ* characterization platforms to provide high-fidelity data on materials performance in realistic, dynamic environments; increased dimensionality (spatial or temporal) to existing characterization techniques; and advanced techniques for rapid collection, extraction, and inversion of data.
 - [Engineering of Materials Reliability, Detection at the Limit, First to High-Yield Fusion RC](#)

MSRF Engagement with Mission Areas

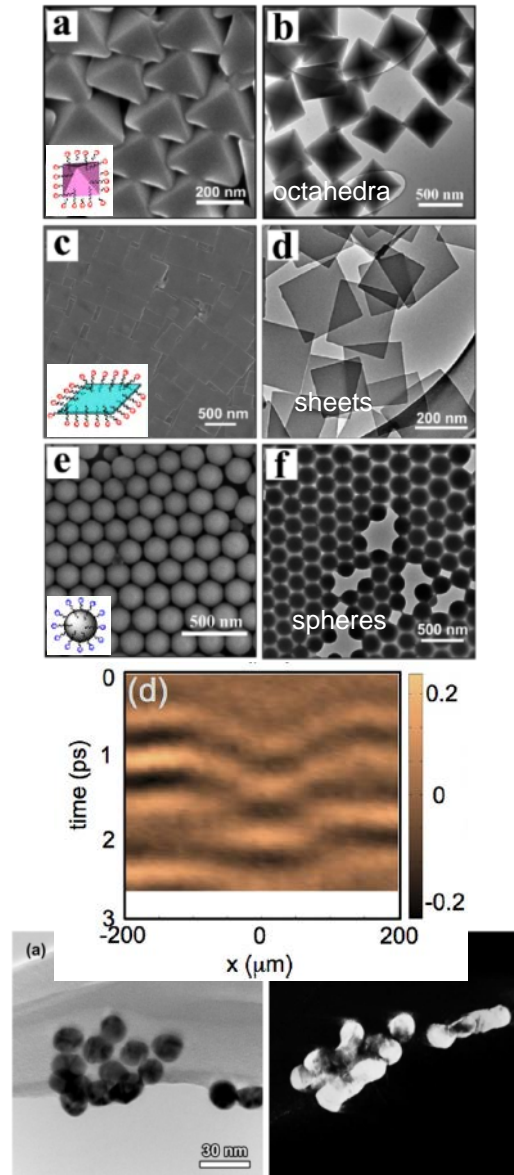


- **Predicting Performance and Reliability:**
 - Predicting performance and margins of mechanical materials (NW)
 - Predicting performance of semiconductor materials in hostile environments (NW)
- **Control of Energy, Mass, and Charge Transfer:**
 - New battery materials and materials aging (SSEF)
 - New functionality from nanoparticles (GCBD, SSEF)
- **New materials, Next Generation Electronics Optoelectronics:**
 - Novel radiation, chemical, and biological detection materials (GND, GCBD)
 - Wide bandgap and Ultra-wide bandgap semiconductors (SSEF, NW, LDP, SDP)
- **Computational Materials Synthesis and Processing:**
 - Predictive aging of neutron generator materials related to synthesis (NW)
 - Modeling and validation of MOCVD growth of compound semiconductors (SSEF)
- **Novel Characterization and Diagnostic Tools and Techniques :**
 - Characterization of plasma material interactions (NW)
 - In-situ TEM analysis of materials in fluid environments (SSEF)

Partnerships With Other Research

Foundations

- Nanodevices and Microsystems: Semiconductor materials.
- Engineering Sciences: Enhanced high-fidelity prediction of mechanical behavior at the microscale and failure of brittle materials.
- Radiation Effects & High Energy Density Science: Radiation effects in semiconductor and nuclear reactor materials, and understanding plasma-material interactions to enable First to High-Yield Fusion.
- Biosciences: Materials for biothreat sensors and biomimetic materials as a route to new functionality from materials.
- Computing and Information Sciences: Math and algorithms to support the Materials Genome Initiative, and materials for Beyond Moore Computing.
- Geosciences: Predictive behavior of geologic materials and materials for clean water solutions.



Strategy Communication

- To the staff
 - Strategy communicated through LDRD information sessions (also recorded for later viewing)
 - Communicated through center and department meetings
 - Research Challenges workshops (recorded for later viewing)
- To management
 - Management involved in creating RF strategy and Research Challenges through numerous workshops
 - Management serves on LDRD investment area decision team
- Upward Communication
 - Quarterly management assurance reviews and regular Research Leadership Team meetings