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Author(s): Sarrao, John Louis

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Navigating a National Lab Career: Science, Technology, & Engineering Priorities at Los Alamos

John Sarrao
Deputy Director

Science, Technology, & Engineering

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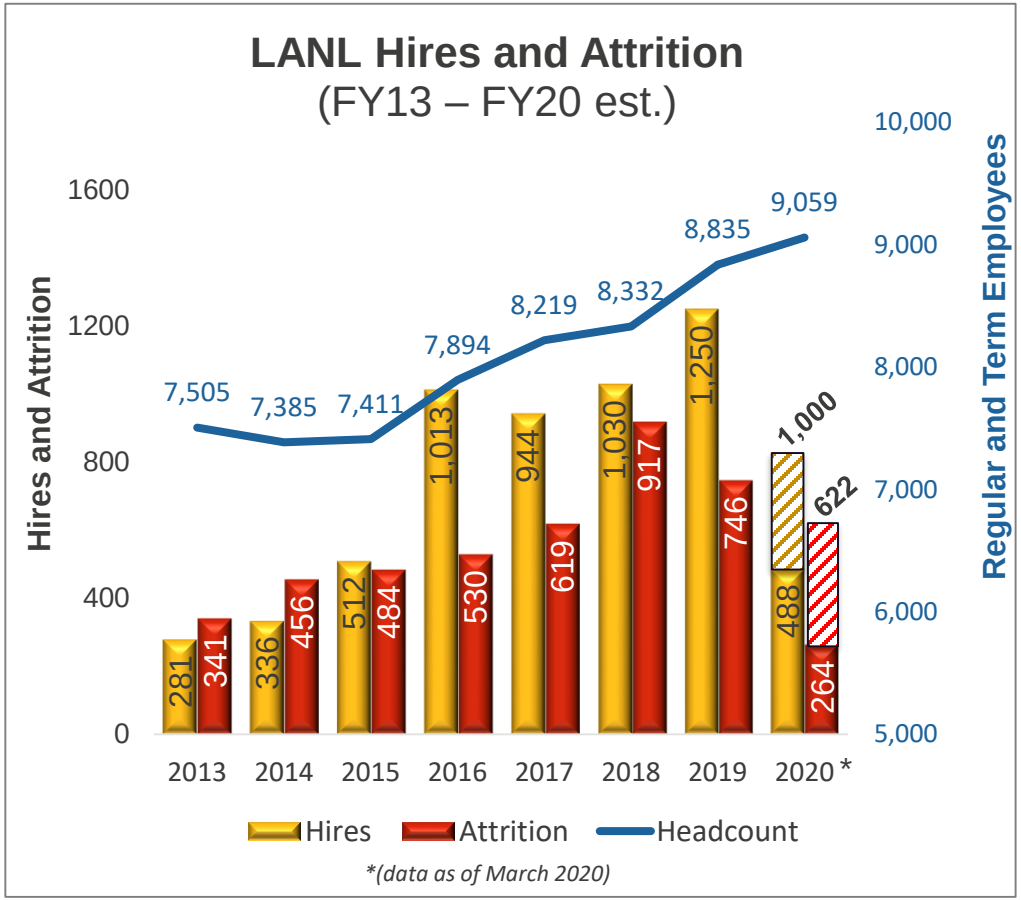
Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

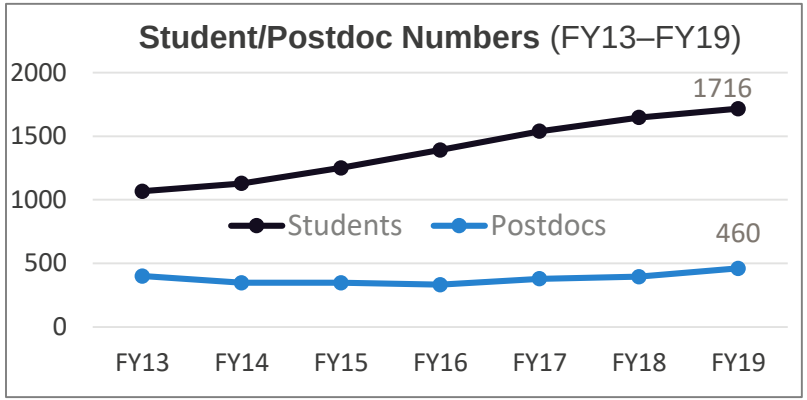
By way of introduction…

- Undergrad: Stanford; Grad Student: UCLA
  - First exposure to National Lab: LLNL, ~ two weeks, ~1988
  - First exposure to LANL: Summer, 1990
  - “Grad school” @ LANL 6/91 - 12/93
- Postdoc: UCSD … Magnet Lab @ FSU
- LANL: 1997-present
  - Full-time research, 1997 - ~2002
  - Part-time research, 2002 - ~2007
  - Zero-time research (i.e., Full-time Manager), 2007 →
    - Materials research; Program Manager & Scientific Facility planning; Theory, Simulation & HPC
    - Today: Deputy Director: ~ 4000 people; ~ $1.5B/year

Budget and employee numbers continue to grow

Continued commitment to student/postdoc programs, diversity initiatives

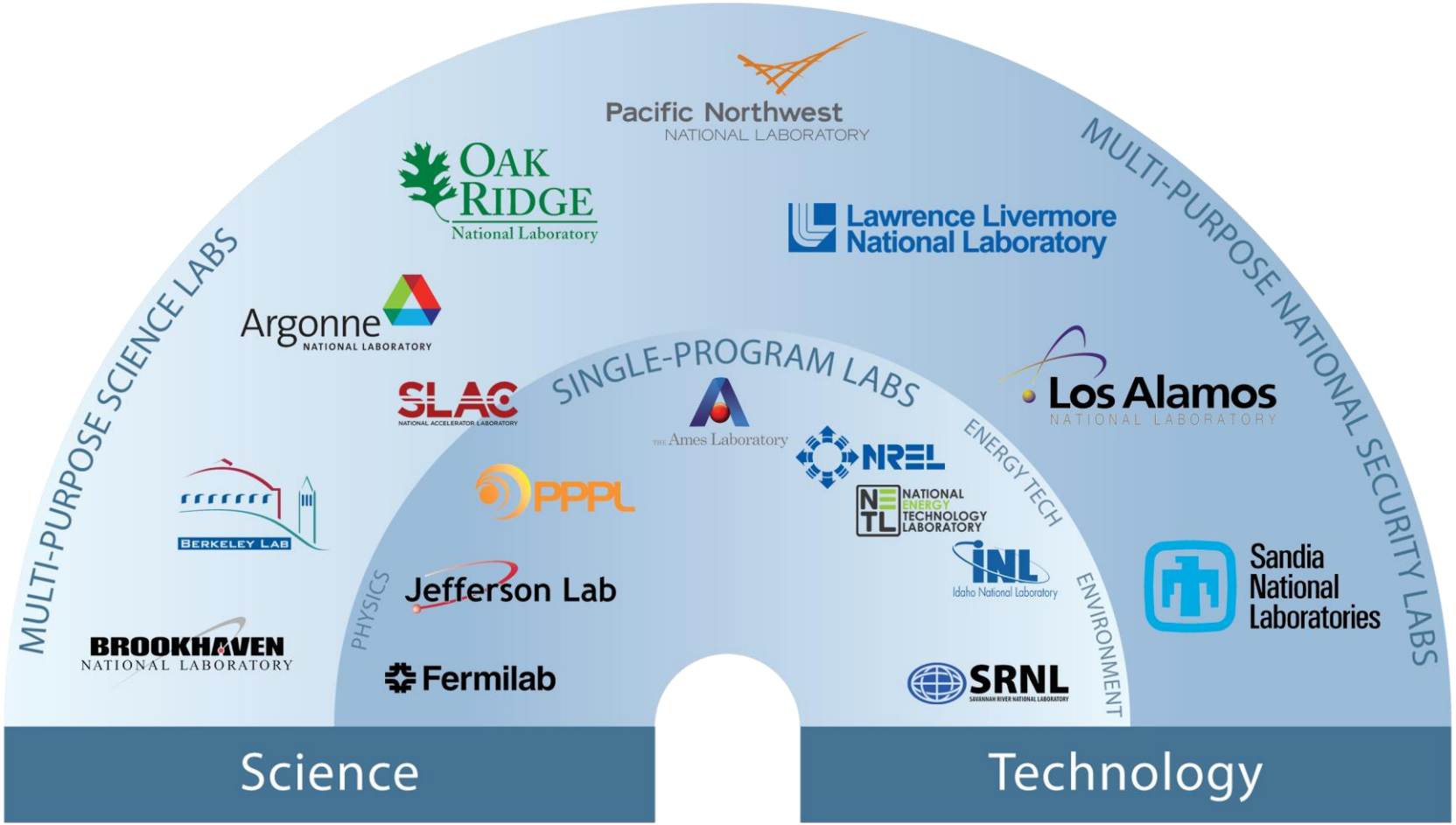




Postdoc Diversity*	LANL	DOE Nat'l Labs
Women	25%	24.4%
Under-represented minorities (URM)	6.4%	8.6%
Other people of color (OPC)	35.3%	36.5%

**2019 (URM: Hispanic, Black, Native American; OPC: Asian)*

Los Alamos is one of 17 Department of Energy national laboratories



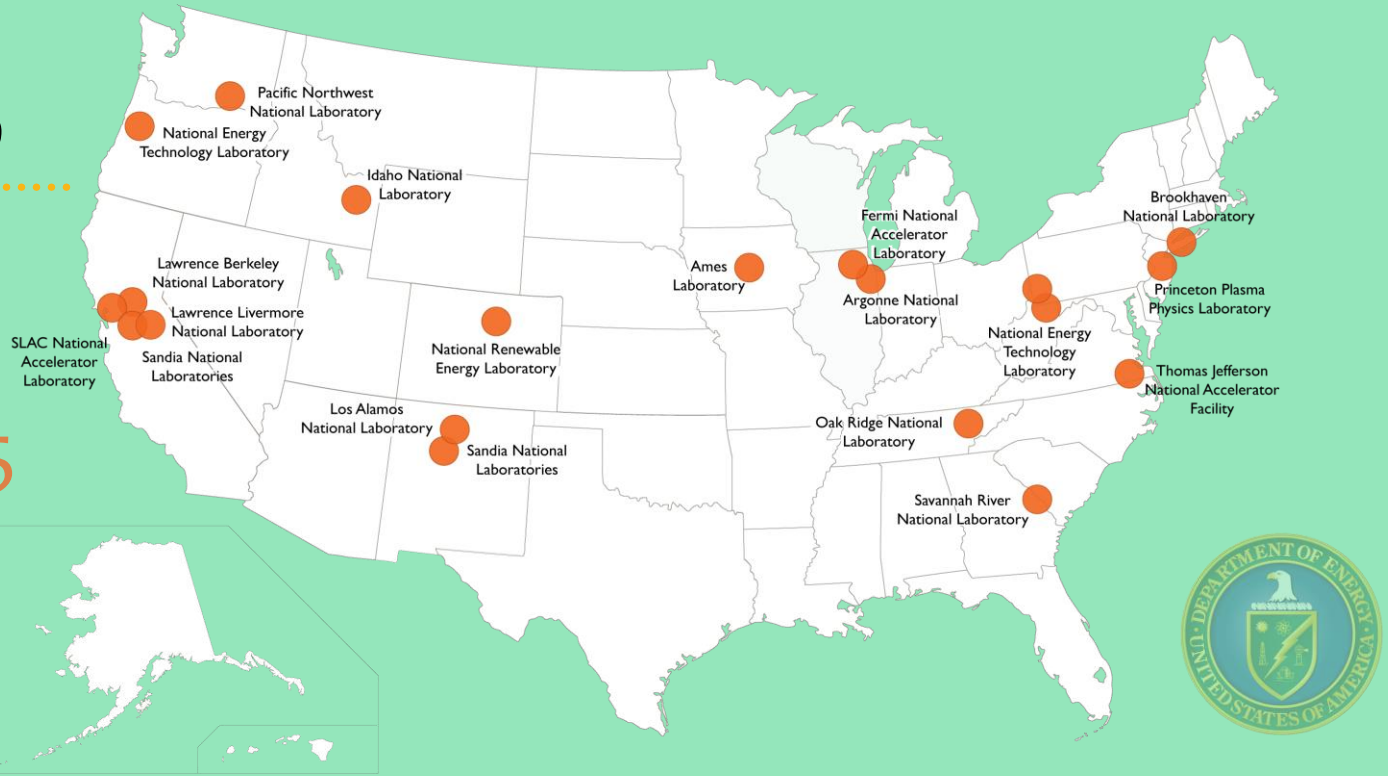
Department of Energy national laboratories are located across the nation

DOE Lab's Overall Demographics – 2019

68,146 total employees

technical research staff **25,095**

9,051 postdocs & grad/undergrad students



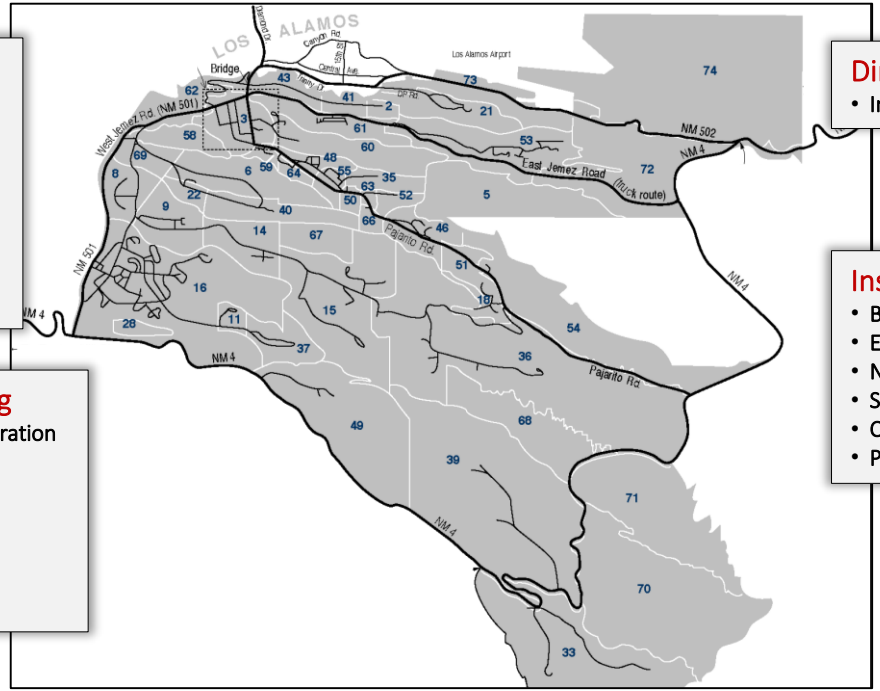
nationallabs.org/staff/diversity

www.energy.gov

The Laboratory is a complex, dynamic system of people, facilities, materials, and services

Weapons Programs
- Weapons Physics Design and Computation
- Weapons Engineering
- High Explosives
- Plutonium
- Tritium/GTS
- Uranium, Beryllium, Salts, Metals
- Detonators
- Component Fabrication and Assembly

Science, Technology & Engineering
- Nuclear Nonproliferation & Counter-Proliferation
- Emerging Threats
- Intelligence Community
- National Defense and Homeland Security
- Chemistry, Earth and Life Sciences
- Materials and Physical Sciences
- Theoretical and Computational Sciences



Director's Office
- Institutional Management

Institutional Operations
- Business Services
- Environmental, Safety, and Health
- Nuclear & High Hazard Operations
- Security and Mission Assurance
- Capital Projects
- Project Management Services

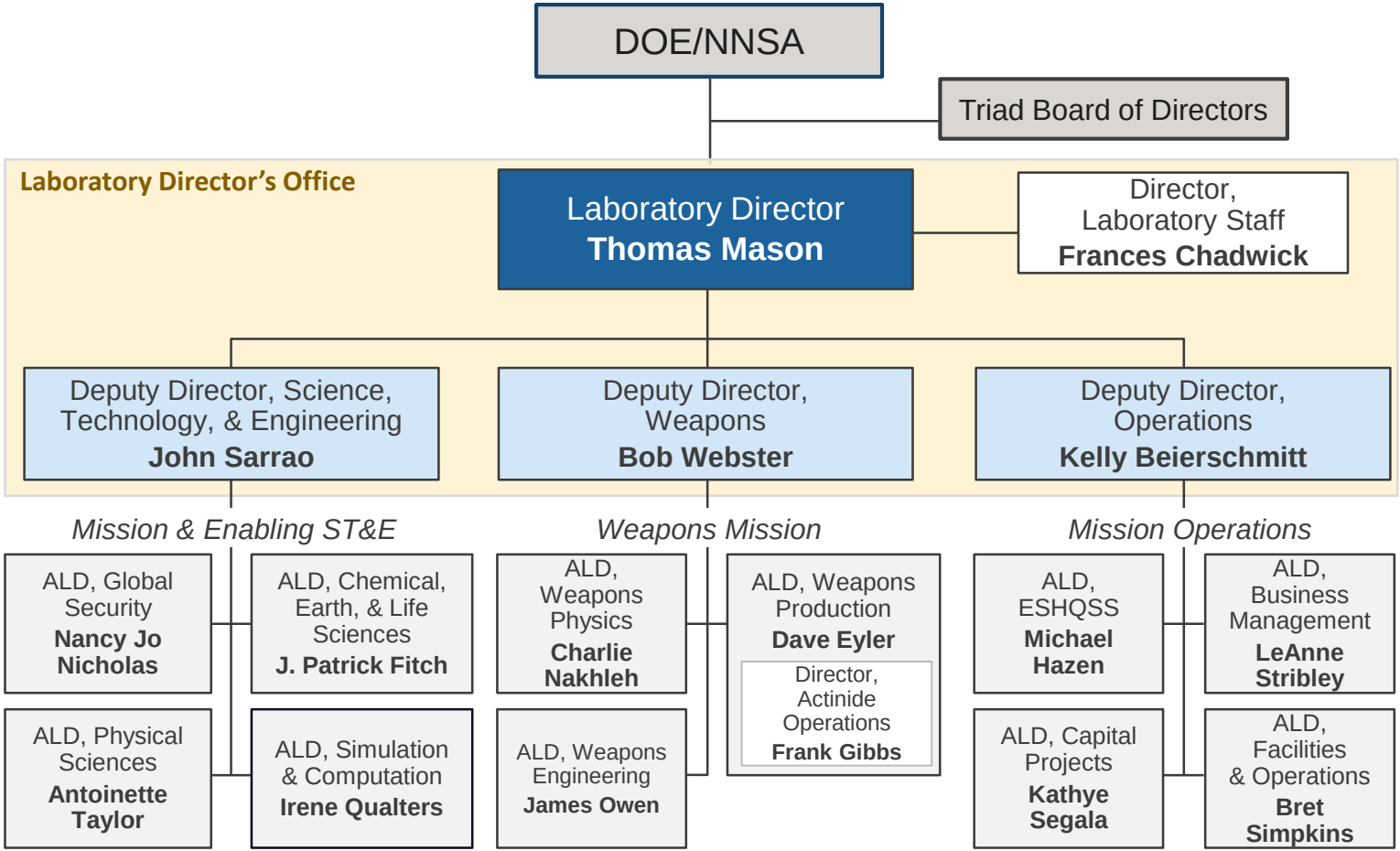
40 square miles 47 technical areas 1,280 buildings/ 9M sq ft 11 nuclear facilities 268 miles of roads

8,400 career employees/12,800 workers on site 2,500 R&D staff 1,100 veterans 450 postdocs 1,850 students

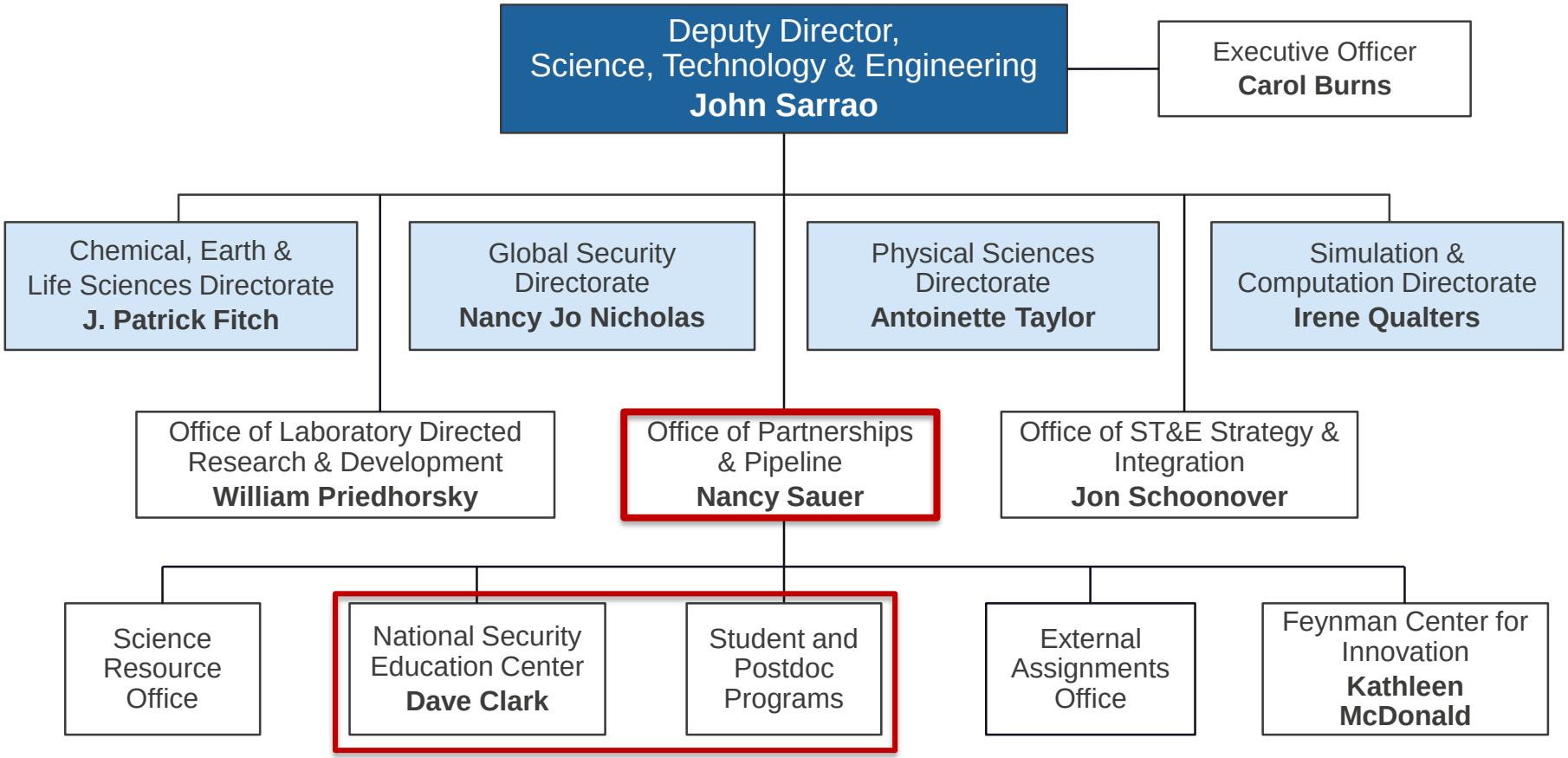
$2.9B budget 4,700 projects 600 B&R codes

11 Directorates 60 Divisions

Los Alamos National Laboratory
Organizational structure



DDSTE organization facilitates capability stewardship and outreach



Simultaneous excellence

Balance between operations and mission

Design, produce, and certify current and future nuclear weapons and reduce global nuclear threats

Deliver scientific discovery and technical breakthroughs that support DOE & NNSA missions

Execute sustained operations that are reliable and responsive to mission needs

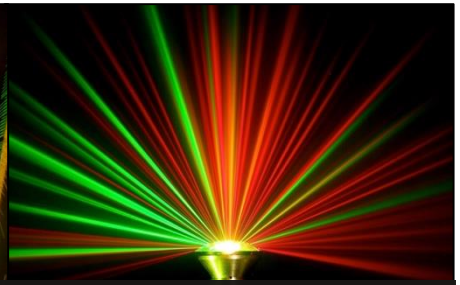
Sustain and enhance LANL's partnership with the community across Northern New Mexico

Culture Statement: HOW we do our work is as important as WHAT we do

Los Alamos' core mission is to ensure the U.S. nuclear deterrent

- Ensure safety, reliability, and performance of U.S. nuclear stockpile
- Design agency for 4 out of 7 warhead systems constituting the nation's deterrent
  - Physics design & engineering
- Significant & growing production responsibilities: detonators, heat sources, Pu pits

Modeling & simulation



Specialized experiments

Supercomputing

DARHT – Dual axis x-ray

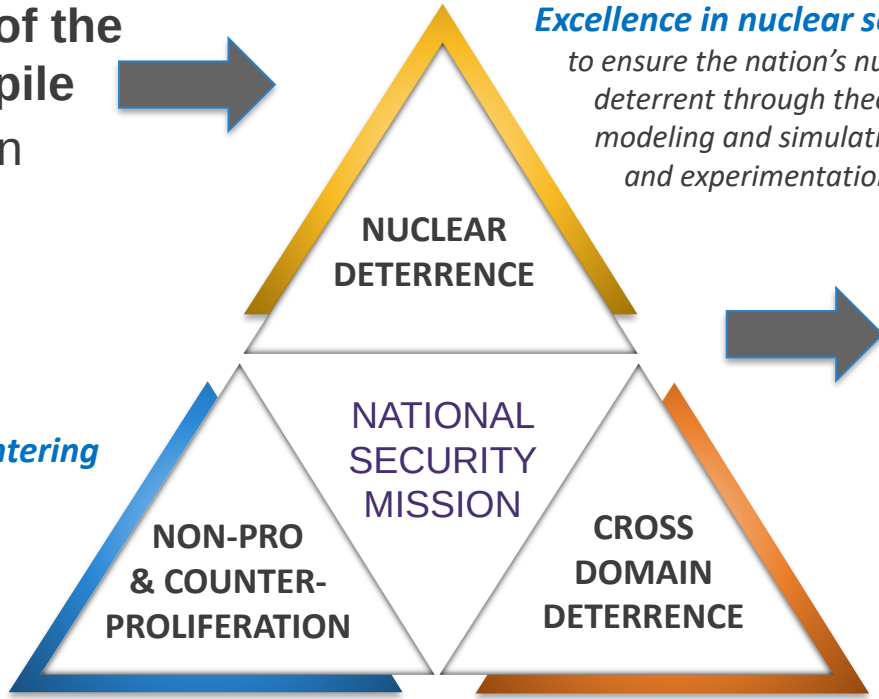
Los Alamos uses scientific assessment, experimentation & modeling to assess and certify the stockpile, which has aged significantly since it was first developed and since the conclusion of full-scale testing

Our national security mission is broad and important
— and motivates and is enabled by ST&E discovery

Ensure the safety, reliability, and performance of the U.S nuclear stockpile

- Physics & Design
- Engineering
- Production

Excellence in nuclear security *to ensure the nation's nuclear deterrent through theory, modeling and simulation, and experimentation*



Preventing and countering *efforts of proliferants to acquire, develop or disseminate materials and expertise necessary for nuclear weapons*

Energy security

- Sustainable Nuclear Energy
- Resilient Materials
- Complexity in Energy Systems

Supporting *the DoD, IC, and other national security partners to execute multidomain operations across land, air, sea, space and cyber*

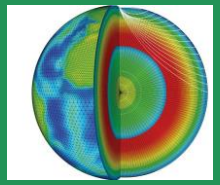
Our capability areas define key areas of science, technology & engineering in which we must lead

Materials for the Future

- Defects and Interfaces
- Extreme Environments
- Emergent Phenomena

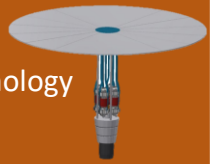
Science of Signatures

- Nuclear Detonation
- Nuclear Processing, Movement, Weaponization
- Natural and Anthropogenic Phenomena



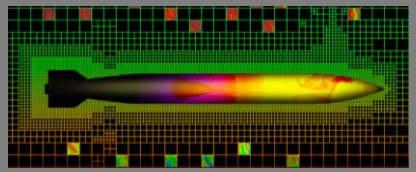
Nuclear and Particle Futures

- High Energy Density Physics & Fluid Dynamics
- Nuclear & Particle Physics, Astrophysics & Cosmology
- Applied Nuclear Science & Engineering
- Accelerator Science & Technology



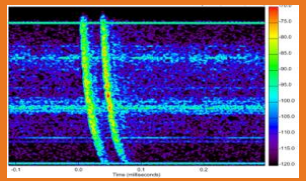
Weapons Systems

- Design
- Manufacturing
- Analysis



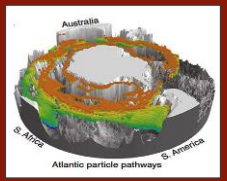
Integrating Information, Science, and Technology for Prediction

- Computing Platforms
- Computational Science
- Data Science

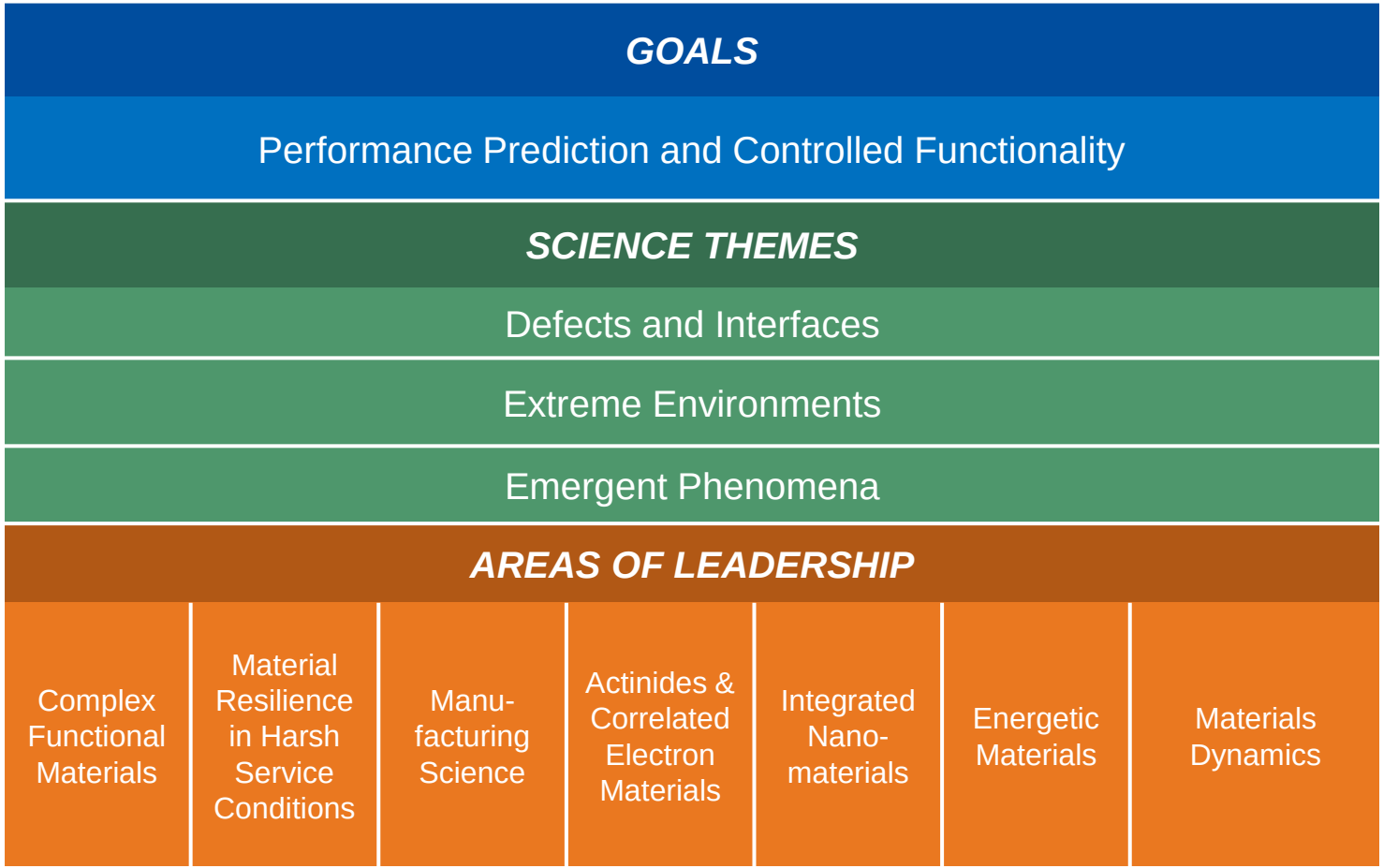


Complex Natural and Engineered Systems

- Human–Natural System Interactions: Nuclear
- Engineered Systems
- Human–Natural System Interactions: Non-Nuclear



Materials for the Future Strategy Links Leadership Areas Through Science Themes to Achieve

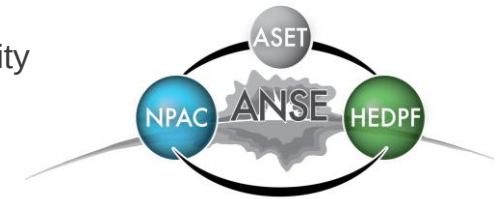


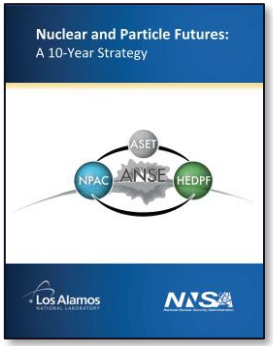
NPF encompasses a broad range of capabilities necessary for LANL to complete its national security science mission

NPF Pillar is composed of four focus areas:

- **Nuclear, Particle, Astrophysics, and Cosmology (NPAC)**
  - The origin and evolution of the universe and the most extreme environments in the universe
- **Applied Nuclear Science and Engineering (ANSE)**
  - The application of nuclear science to national security
- **High-Energy-Density Plasmas and Fluids (HEDPF)**
  - The hydrodynamics, thermodynamics, and kinetic behavior of fluids and plasmas
- **Accelerator Science, Engineering, and Technology (ASET)**
  - A foundational capability needed to meet our national security mission with connections to basic science activities as well.

The primary goals of the NPF Pillar are to steward, develop, and integrate our foundational capabilities in particle physics, accelerators, applied and fundamental nuclear physics, fluid dynamics, plasma physics, astrophysics, and cosmology to solve the nation's most difficult challenges.





The 10 year goals for IS&T Pillar are being defined in a strategic planning process

- **Transform Simulation**
  - Develop innovative, multi-physics, multi-scale methods and solutions that increase simulation fidelity, are efficient on modern architectures, and are suitable to applied problems of national interest.
- **Data-driven Scientific Discovery**
  - Engineer a full toolchain of artificial intelligence, data management, streaming, interactive, and large-scale data analysis mechanisms targeted to routinely extracting enhanced knowledge and achieving the ten-year goals of other LANL pillar goals
- **Information Integrity**
  - Develop methods to assure the integrity of data, information, and analytical tools including artificial intelligence to ensure the correctness of scientific inferences, discoveries, and decisions made from data.
- **Quantum Computing**
  - Execute applications of mission relevance on large, fault-tolerant, modular quantum computers. Be recognized as a major influence in quantum algorithm development across the entire software stack for both fault-tolerant quantum computers and NISQ devices

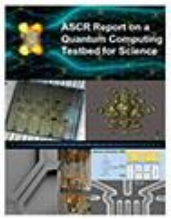
We believe "physics-informed" machine learning is a differentiator

In Situ Data Management

Scientific Machine Learning

Data and Models

Storage Systems and I/O



Quantum Computing


Scientific Computing Integrity

Science of Signatures (SoS) Pillar science themes address challenges

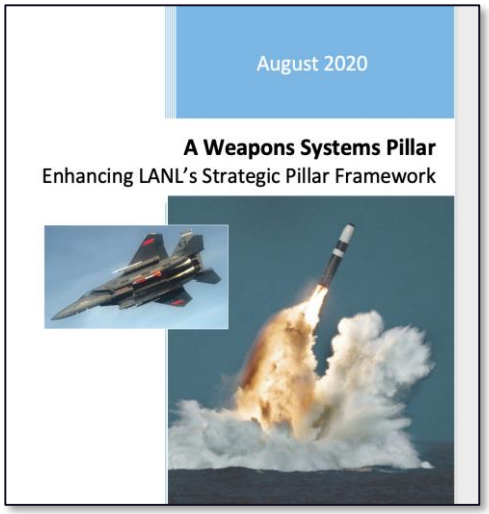
- **Discover signatures that (in complex environments) can**
  - Be extracted to detect and characterize chemical, biological, radiological, nuclear, and explosives threats
- **Revolutionize measurements through**
  - New technologies, methodologies, or strategies that enable transformational advance in performance of measurement systems and derived information
  - Systems that exploit novel data-to-knowledge approaches
  - Measure new phenomena (signatures)
- **Deploy to unusual or extreme field environments through**
  - Engineering and applied science for prototyping, demonstration, field deployment, and technology transfer to public, private, and government sectors
  - Transformational resource reduction (size, weight, power, communications) while maintaining or even increasing system performance

Address challenges in national security, energy/climate, and health

Weapons Systems Pillar focuses on integrated, systems-level, weapons physics, engineering, and manufacturing

The most recent Nuclear Posture Review foreshadows a transformation

LEP era →	Post-LEP era
Optimized for Yield/weight	Optimize for certifiable and manufacturable
Aging to many decades not considered in original design (LEPs needed)	Sustain an aging stockpile
Slow (since 1992)	Responsive - must become agile, quick
Post-1992 stewardship experimental/ computing built; used with UGTs of original design, and “similitude”	Modern experiments, modeling, and simulation that increasingly account for weapons-relevant regimes
Focused on predictive capability & eliminating knobs	Enable modular design, qualification, certification & manufacture
MAD deterrent derived from 1980s stockpile	Resilient deterrent customized to 21st century evolving threat space



R&D Focus Areas:

- Design & system integration
- Production/Design for Manufacture
- Systems Analysis

CNES is Organized into Three Strategic Challenges

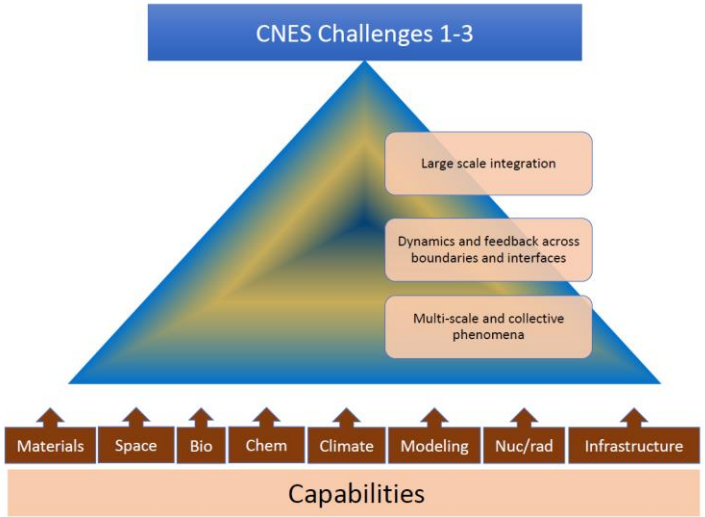
- **Challenge #1 - Explain the complex interactions and resulting impacts between natural environments and human actions from nuclear threats.**
  - **10-year goal:** Understand and predict the effects of nuclear events on natural environments (Earth's core to space).
- **Challenge #2 - Design, build, protect, predict and control engineered systems.**
  - **10-year goal:** Develop sufficient predictive ability to enable improved resilience in design of engineered systems or, where applicable, to develop the means to maintain positive control even outside of design lifetime or specification.
- **Challenge #3 - Explain the complex interactions and resulting impacts between natural environments and human actions involving non-nuclear threats.**
  - **10-year goal:** Establish science-based models and systems of human-environment interactions representing natural threats and anthropogenic non-nuclear threats that inform national policy and decision makers.

Interactions between natural environments and human actions

#1 For nuclear threats

#2 Design, build, protect, predict, and control engineered systems

#3 For non-nuclear threats



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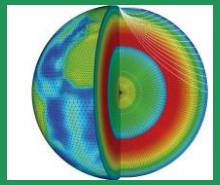

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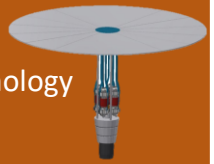

Weapons Systems

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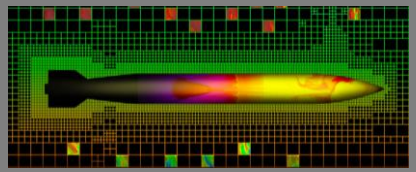
Manufacturing

Analysis

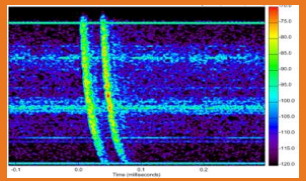


Integrating Information, Science, and Technology for Prediction

Computing Platforms

Computational Science

Data Science



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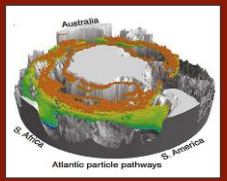

FY21 Lab Agenda

SIMULTANEOUS EXCELLENCE	1.0 NUCLEAR SECURITY	2.0 MISSION-FOCUSED SCIENCE, TECHNOLOGY & ENGINEERING	3.0 MISSION OPERATIONS	4.0 COMMUNITY RELATIONS
Strategic Objective (10–20 years)	Excellence in Nuclear Security	Excellence in Mission-Focused Science, Technology & Engineering	Excellence in Mission Operations	Excellence in Community Relations
Critical Outcomes (5–10 years)	Design, produce, and certify current and future nuclear weapons and reduce global nuclear threats	Deliver scientific discovery and technical breakthroughs that support DOE and NNSA missions	Execute sustained operations that are reliable and responsive to mission needs	Sustain and enhance LANL's partnership with the community across the Northern New Mexico region
Major Strategic Initiatives (1–5 years)	1.1 Execute LANL's Manufacturing mission to deliver 30 plutonium pits per year 1.2 Transform nuclear weapons warhead design and production 1.3 Anticipate threats to global security; develop and deploy revolutionary tools to detect, deter, and respond 1.4 Support modernization of LANL warhead systems 1.5 Assess the stockpile as it ages and project weapon system lifetimes	2.1 Refine and enhance the LANL capability pillar framework 2.2 Advance accelerator science, engineering, and technology to enable future stewardship capabilities 2.3 Advance the frontiers of computing to exascale and beyond 2.4 Assert leadership in the national quantum initiative 2.5 Develop and implement an integrated nuclear energy and nuclear materials initiative 2.6 Implement an integrated initiative for plutonium and actinide missions based on FY20 strategy 2.7 Implement a national security life sciences initiative	3.1 Change organizational culture with an emphasis on organizational learning 3.2 Improve integrated planning across priority mission activities and infrastructure 3.3 Address critical issues related to NMCA, nuclear safety, criticality safety, waste, and classified enhancements 3.4 Implement systematic process improvement to drive increased rigor and efficiency in work execution 3.5 Enhance quality of work life, workforce planning, and training and development	4.1 Continue commitment to the community with educational, economic, and philanthropic investments of time and resources 4.2 Strengthen pipelines and partnerships to build the workforce of the future 4.3 Enhance small business participation in executing LANL scope across all directorates 4.4 Demonstrate agility and flexibility in our partnerships, effectively balancing benefit and risk

FY21 Lab Agenda

1.0 NUCLEAR SECURITY	2.0 MISSION-FOCUSED SCIENCE, TECHNOLOGY & ENGINEERING
Excellence in Nuclear Security	Excellence in Mission-Focused Science, Technology & Engineering
Design, produce, and certify current and future nuclear weapons and reduce global nuclear threats	Deliver scientific discovery and technical breakthroughs that support DOE and NNSA missions
1.1 Execute LANL's Manufacturing mission to deliver **30 plutonium pits per year** 1.2 **Transform nuclear weapons warhead design** and production 1.3 **Anticipate threats** to global security; **develop and deploy revolutionary tools** to detect, deter, and respond 1.4 Support modernization of LANL warhead systems 1.5 Assess the **stockpile** as it **ages** and project weapon system **lifetimes**	2.1 Refine and enhance the LANL capability pillar framework 2.2 Advance **accelerator science, engineering, and technology** to enable future stewardship capabilities 2.3 Advance the **frontiers of computing** to exascale and beyond 2.4 Assert leadership in the **national quantum initiative** 2.5 Develop and implement an integrated **nuclear energy and nuclear materials initiative** 2.6 Implement an **integrated initiative for plutonium and actinide missions** based on FY20 strategy 2.7 Implement a **national security life sciences** initiative

Partnerships & Pipeline Office (PPO) was formed to enhance our internal coordination and external outreach

Pipeline

Partnerships

Pipeline Mechanisms:

- **Student Programs:** Education opportunities for high school, undergraduate, and graduate students
- **Postdoctoral Programs:** Postdocs contribute to research efforts, enhance our STE capabilities

Partnership Opportunities:

- **National Security Education Center Strategic Centers:** Scientific centers of excellence with high international visibility that innovate strategic new science and education programs
- **New Mexico Consortium Coordination:** Creative mechanisms for collaboration with NM research universities through joint appointments and unique facilities
- **Feynman Center for Innovation:** From “tech transfer”’ to innovation asset stewardship with strategy driven through Innovation Asset Strategic Council

National Security Education Center Strategic Centers

Gateways for collaboration, education, and recruitment

- **Center for Nonlinear Studies**
  Interdisciplinary science of complex systems
- **Center for Space and Earth Science**
  Astrophysical, space, earth, & climate sciences & their signatures
- **Engineering Institute**
  UCSD collaboration in Structural health monitoring, cyberphysical systems
- **Information Science & Technology**
  Education, collaboration, research in IS&T
- **Institute for Materials Science**
  Advancement of interdisciplinary materials science
- **Seaborg Institute**
  Actinide science & Plutonium Center of Excellence

Joint Center for Resilient National Security

How can you get started (@ LANL and in DOE)?

Undergraduate & Graduate Student Programs

Emily Robinson, errobinson@lanl.gov

Postdoc Programs

Mary Anne With, with@lanl.gov

National Security Education Center

Dave Clark, dlclark@lanl.gov

TAMUS National Laboratories Office (https://nationallabsoffice.tamus.edu/)

Diane Hurtado, d-hurtado@tamu.edu

If all else fails, sarrao@lanl.gov (or right now, via chat, etc.)

LANL continues to be essential to the nation's security

Los Alamos delivers national security mission solutions

- By applying multidisciplinary science, technology & engineering capabilities, in unique experimental, computational, and nuclear facilities
  - With a diverse, responsive, and innovative workforce
    - Dedicated to addressing complex national security issues and the world's most difficult challenges