

Los Alamos National Laboratory

Laboratory Directed Research and Development

FY20 Annual Progress Report

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LABORATORY DIRECTED
RESEARCH & DEVELOPMENT
WHERE INNOVATION BEGINS

Structure of this Report

The Laboratory Directed Research and Development (LDRD) annual report for fiscal year 2020 (FY20) consists of an overview and a stand-alone compendium of FY20 project summaries.

Overview: A description of the LDRD program at Los Alamos National Laboratory (LANL), including the program's structure and objectives; a summary of the program's value; and highlights of outstanding program accomplishments.

Project Summaries: The project summaries are compiled in a stand-alone document. The summaries are organized by Capability Pillar – Complex Natural and Engineered Systems, Information Science and Technology, Materials for the Future, Nuclear and Particle Futures, and Science of Signatures. Project summaries for continuing projects appear first, followed by project summaries and technical outcomes for projects that ended in FY20.

Both the Overview and Project Summaries are available at <https://www.lanl.gov/projects/ldrd-tri-lab/annual-reports.php>.

Cover image: LDRD researcher Hou-Tong Chen tests his metamaterial inventions in an anechoic chamber. The chamber is designed with foam spikes on the walls, floor, and ceiling to absorb electromagnetic waves and prevent reflections to simulate a wide empty space—effectively, a room with no walls. Learn more in this [article](#) in 1663 magazine. (Chen, 20200419ER)

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Leadership Perspectives

“LDRD is central to Los Alamos science, technology, and engineering strategy as articulated in our Laboratory Agenda and through our Capability Pillars, and I cannot imagine being successful without it. Our LDRD objectives of advancing mission agility, technical vitality, and workforce development align with and derive from this strategy. Because of LDRD's importance we must also ensure that we execute our LDRD program with the highest standards of transparency, objectivity, and inclusion, and an unwavering commitment to robust peer review.”

– **John Sarrao**, Deputy Director for Science, Technology, & Engineering

LDRD Program Director **Bill Friedhorsky**



As I write, the LDRD Office is reviewing proposals for FY22, which will be the 15th year of selections that I have had the privilege to oversee. I am convinced that the LDRD program at Los Alamos is stronger than it has ever been, enabling work at the cutting edge of discovery that changes the way the Laboratory can carry out its mission. Much of our work is carried out by a new generation of science and engineering talent; their ranks include the leaders who will take the Laboratory well into its second century.

Thanks to a readjustment of responsibilities in our LDRD Office, I have interacted with parts of the program that were new to me. What I saw was dedication and excellence serving every mission and every capability of the Laboratory. Rather than describe the work myself, I would like to share the assessments of a few LDRD projects by independent panels:

“...positioning [LANL] at the forefront of innovation in targeting bio-threats could not be more appropriate ... ‘Wow’ and ‘fantastic’ are just two examples of overall descriptors from committee members.”

“The record of publications and collaboration is stunning. In just over two years the project has led to almost 50 papers, a number of which have led to major press releases, written with some of the best astrophysicists in the world.”

“The results are impressive, in particular regarding the first direct observation of the earthquake propagation, and represent a major advance in understanding geoscience.”

“The nanowire capability is pioneering a new approach to studying quantum phenomena.”

“This work is at the forefront of magnetospheric physics and represents a major advance for the field.”

How LDRD can change the world came home to me this month when, with millions of others, I held my breath as I watched the landing of the Perseverance rover, its search for life on Mars made possible by the SuperCam probe. SuperCam is the child of LDRD investments that carried Laser Induced Breakdown Spectroscopy, in measured steps, from concept to Mars and, someday, beyond.

LDRD Deputy Director Laura Stonehill

“The Exploratory Research (ER) Refresh has produced creative and innovative ideas for concrete and substantive improvements to ER through committee consensus on foundational principles and specific recommendations. These adjustments will allow the ER component to further build on its greatest strengths.”

– Laura Stonehill, LDRD Program Deputy Director



FY20 has been a highly productive year. Despite the challenges from a global pandemic, the LDRD Program continues to reach new levels of excellence, driving significant mission-aligned achievements across the Laboratory.

Notably, the Exploratory Research component, a largely bottom-up process, was thoughtfully evolved in a refresh process in FY20, the first since 2014. The ER Refresh committee evaluated how to adapt ER to changing Lab needs. Some of the key outcomes involved clearly differentiating ER from the other components of LDRD, ensuring ER includes enough potentially transformative research and an appropriate balance of basic and applied research, and ensuring ER is reaching the right demographics across the Laboratory. The Refresh Committee particularly focused on how to better encourage and then select the best ER projects, while balancing the burden on the peer reviewers.

Speaking of peer review, LDRD holds an exceptionally high standard for the peer review of LDRD proposals. This year the LDRD Program Office improved on the nomination process for peer reviewers to ensure peers selected have the appropriate expertise to review LDRD proposals. LDRD is leading the pack on exploring new, innovative ways to associate reviewer expertise with proposals. Every day I am struck by the degree of rigor LDRD exercises at every stage of a project—from selection through transition.

The impact from this rigor is evident in many of the metrics you will see throughout this report. While LDRD was funded with just 5.5% of the Laboratory budget in FY20:

- 55% of all postdocs at the Laboratory were partially supported by LDRD. LDRD is critical to supporting these post-doctoral researchers as they transition to staff and programmatic work.
- 44% of LANL peer-reviewed publication citations were derived from publications supported by LDRD.
- 75% (6 of 8) R&D 100 awards granted to Los Alamos have roots in LDRD investments.

Your support of LDRD at Los Alamos helps sustain our ability to deliver agile solutions to the Nation’s current/future security threats.

Program Description

LDRD Directives, Objectives, and Strategic Challenges

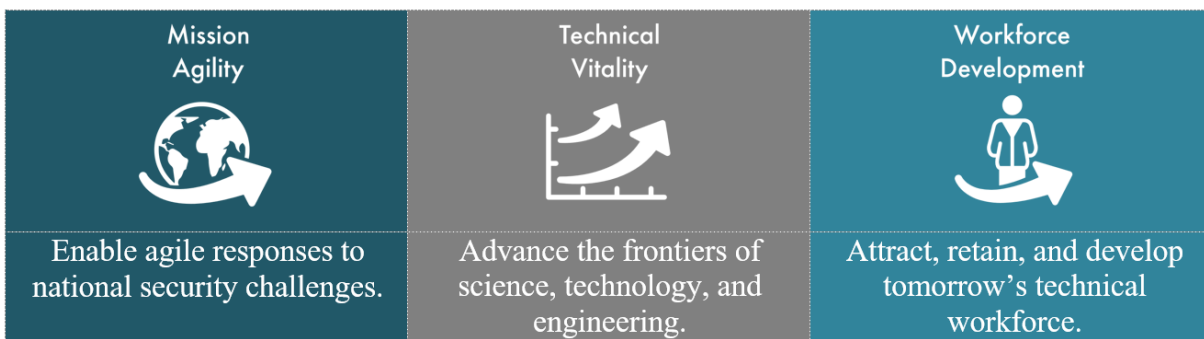
Laboratory Directed Research and Development (LDRD) at Los Alamos helps Los Alamos National Laboratory solve national security challenges through excellence in mission-focused science, technology, and engineering. The Laboratory and Site-Directed Research and Development programs are among the most impactful sources of research and development for our Nation. At Los Alamos, Lawrence Livermore, and Sandia National Laboratories, the Laboratory Directed Research and Development (LDRD) programs are important sources of internal investment in science and technology for the future. The Nevada National Security Site (NNSS) conducts applied science and technology research and development through the congressionally authorized Site-Directed Research and Development (SDRD) program. The LDRD and SDRD programs follow strategic guidance derived from the missions of the U.S. Department of Energy, the National Nuclear Security Administration (NNSA), and the Laboratory.

To execute that strategy, the Los Alamos LDRD program creates a free market for ideas, drawing upon the creativity of the Laboratory’s best and brightest researchers. The combination of strategic guidance and grassroots competition provides a continual stream of capabilities that position the Laboratory to enable agile responses to national security challenges.

Funded with less than 6 percent of the Laboratory’s operating budget, the LDRD program makes it possible for our scientists and engineers to pursue cutting-edge research and development in support of mission. This in turn helps the Laboratory, and the Nation, maintain its position of scientific and technological leadership.

LDRD objectives guide the program overall and align with DOE Order 413.2C Chg1. The LDRD program has three objectives: Technical Vitality, Mission Agility, and Workforce Development.

The Program’s Objectives Align with DOE Objectives for LDRD



In 2019, DOE/NNSA prepared a [Strategic Framework for the Laboratory- and Site-Directed Research and Development program](#), which communicates NNSA's strategy for developing science and technology tools and capabilities to meet current and future national security challenges. The 2019 LDRD/SDRD Strategic Framework was drafted to convey the vision and objectives of the program and to demonstrate the firm commitment of NNSA leadership to the program.

The LDRD program responds to four national security challenges identified in the Strategic Framework (and derived from the 2018 Nuclear Posture Review).

The Program Responds to Four National Security Challenges

1. *Provide an agile, flexible, and effective nuclear deterrent.*
2. *Protect against all weapons of mass destruction threats.*
3. *Deter and defend against threats in multiple domains.*
4. *Strengthen our energy and environmental national security.*

This report will illustrate the Los Alamos LDRD program’s success in responding to the National Security Challenges and meeting the LDRD objectives noted above.

LDRD Program Values

How we do our work is as important as what we do, in LDRD and elsewhere. The Laboratory assumes the responsibility for stewarding public resources when it oversees the LDRD program. When it succeeds, it delivers the nation full worth in all three objectives. Rigor in LDRD oversight reinforces the reputation of the Laboratory and the LDRD program. LDRD processes, though complicated in some details, are therefore driven by a small set of underlying values based on a commitment to excellence, transparency, and diversity/inclusion, all consistent with the Laboratory’s [values](#).

LDRD Aligns with Laboratory Strategy

LDRD is Organized Around the Los Alamos Capability Pillars

LDRD is essential for the technical vitality of the Laboratory and builds capabilities for future mission challenges. The Laboratory's Capability Pillars define strategic investment areas at Los Alamos for present and future missions. All LDRD investments are aligned with the Capability Pillars. See the Appendix for a project-by-project summary where projects are categorized by Capability Pillar.

In FY20, the Capability Pillars grew from four to six. Beginning with proposal calls released in FY21, LDRD will align with all six Pillars. Note: Prior to FY21, LDRD aligned with "Focus Areas," rather than directly to the Capability Pillars. The Capability Pillars also form the strategic basis for the annual Strategic Investment Plan (SIP), which principally informs LDRD's flagship investment component—Directed Research.

The Capability Pillars Define Six Key Areas of ST&E in which the Laboratory Must Lead

CAPABILITY PILLARS	MATERIALS FOR THE FUTURE	Defects and Interfaces Extreme Environments Emergent Phenomena
	NUCLEAR AND PARTICLE FUTURES	Applied Nuclear Science & Engineering Nuclear & Particle Physics, Astrophysics & Cosmology Accelerator Science & Technology High Energy Density Physics & Fluid Dynamics
	INTEGRATING INFORMATION, SCIENCE, AND TECHNOLOGY FOR PREDICTION	Computing Platforms Computational Methods Data Science
	SCIENCE OF SIGNATURES	Nuclear Detonation Nuclear Processing, Movement, Weaponization Natural and Anthropogenic Phenomena
	COMPLEX NATURAL AND ENGINEERED SYSTEMS	Human–Natural System Interactions: Nuclear Engineered Systems Human–Natural System Interactions: Non-Nuclear
	WEAPONS SYSTEMS	Design Manufacturing Analysis

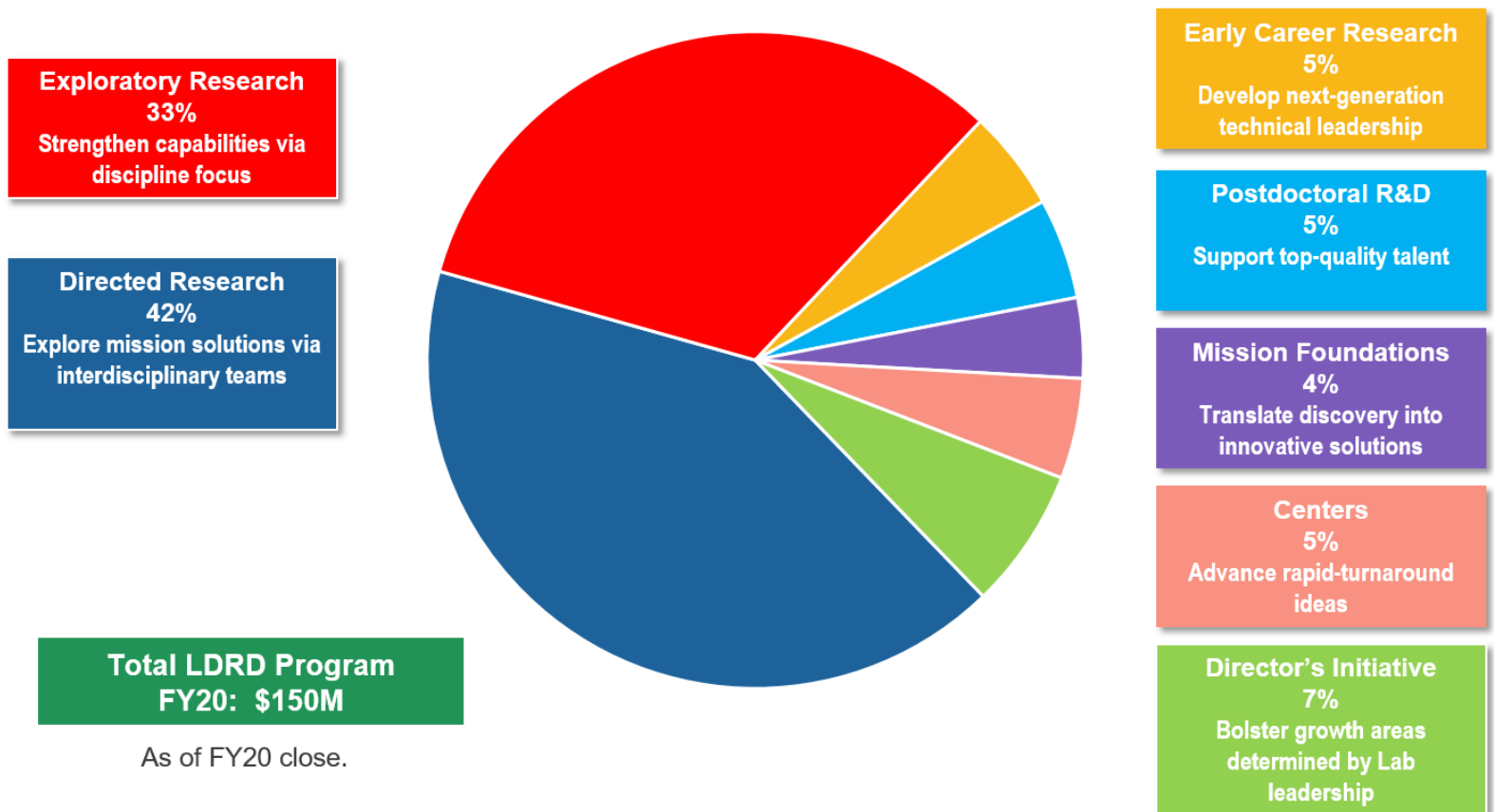
Program Structure

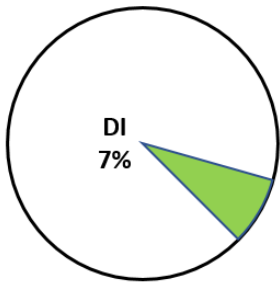
Overview

The Los Alamos LDRD program is organized into seven components with distinct institutional objectives: Directed Research (DR), flagship investments in mission solutions; Exploratory Research (ER), staff-initiated and focused on a single discipline or capability; Early Career Research (ECR), cultivating the Laboratory’s incoming staff; Postdoctoral Research and Development (PRD), recruiting bright, qualified scientists and engineers; Mission Foundations Research (MFR), translating discovery to mission application; Director’s Initiatives (DI), focusing R&D on strategic initiatives of the Laboratory Agenda; and Centers Research (CR), infusing new ideas and people into the Laboratory. All seven components are discussed in detail in this plan.

In FY20, the LDRD program allocated \$150M to 398 projects that incurred total costs of \$147M. These projects were selected through a rigorous and highly competitive peer review process and are reviewed formally and informally throughout the fiscal year. The LDRD Program Office holds a reserve each year to make modest investments that address new opportunities. In FY20, the beginning-of-year reserve budget was approximately \$11.83M, most of which was committed well before year-end.

LDRD Allocations at FY20 Year-end by Component





Director's Initiatives

In FY20, LDRD funded 20 DI projects, investing 7% of the program's research funds.

LDRD Director's Initiatives are strategic efforts first implemented in FY19. The Initiatives focus on strategic objectives within the Laboratory Agenda. 16 of those projects started in FY20 and respond to seven Agenda objectives (see the figure below).

The senior Laboratory leaders responsible for each objective work with the LDRD Program Office and the Deputy Director for Science, Technology, and Engineering to identify strategic growth areas and potential projects. Director's Initiatives may be executed as either special projects or special calls. In either case, Director's Initiatives submit a proposal that is peer reviewed by independent reviewers, following criteria derived from the LDRD mission objectives. The duration of Director's Initiatives is between one and three years.



FY20 Laboratory Agenda Objectives Supported by LDRD Director's Initiatives

1.2

- Beyond the Hugoniot: Dynamic Strength and Damage in Polymers
- Launch Vehicle Detection and Tracking System
- Design for Manufacture Pit Feasibility Study
- Advanced Algorithms for Multiphysics Applications on Modern Computer Architectures

1.3

- Nuclear Material Control and Accounting (NMC&A)/In-line Monitoring Capability (DYnamic MAterials Control, DYMAC)

1.2/1.4

- Expedited High Explosive Formulation Through Processing-structure-property-performance Relationships

NUCLEAR SECURITY		MISSION-FOCUSED SCIENCE, TECHNOLOGY, AND ENGINEERING	
Excellence in Nuclear Security		Excellence in Mission-Focused Science, Technology, and 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	2.1	Refresh and refine the LANL capability pillar framework
1.2	Transform nuclear weapons warhead design and production	2.2	Advance accelerator science, engineering, and technology to enable future stewardship capabilities
1.3	Anticipate threats to global security; develop and deploy revolutionary tools to detect, deter, and respond	2.3	Advance the frontiers of computing to exascale and beyond
1.4	Support modernization of LANL warhead systems	2.4	Assert leadership in the national quantum initiative
1.5	Assess the stockpile as it ages and project weapon system lifetimes	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

2.2

- Adaptive Machine Learning for Advanced Diagnostics and Autonomous Control of Particle Accelerators Launch Vehicle Detection and Tracking System

2.3

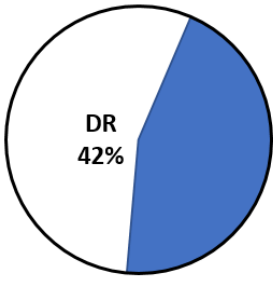
- Trustworthy and Reliable Machine Learning
- Artificial Intelligence for Sensing

2.4

- Quantum Algorithm Development for Optimization
- Hybrid Materials Architectures for Quantum Information Science

2.6

- Investigation of the Role of Actinides on the Local Structure of Molten Salts Using Neutron Pair-distribution Function Analysis
- Atomic Armor Protecting Plutonium
- Accelerated Development of Additively Manufactured Uranium Oxide (UO₂) Fuels for Geometries Avoiding Fuel Lifetime-limiting Irradiation Swelling Using Bulk Neutron Characterization
- Formation of Actinide Amalgams from Ionic Liquids
- Ultrasonic Filtration: A Revolutionary Technology for Hydroxide Precipitation



Directed Research


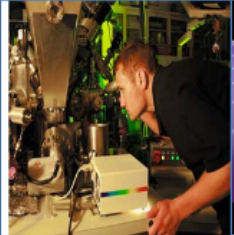
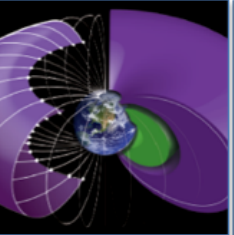

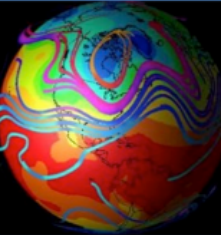
In FY20, LDRD funded 45 DR projects, investing 42% of the program’s research funds.

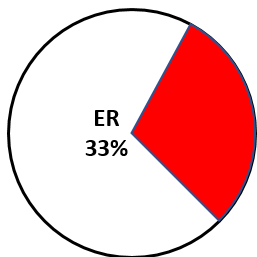
The DR component is LDRD’s flagship investment and makes long-range investments in multidisciplinary projects in key competency or technology-development areas vital to LDRD’s long-term ability to enable the Lab to execute its missions. DR projects are typically funded at up to \$2M per year for three years.

Annual planning for DR directly ties to the Capability Pillars. Priorities within each Capability Pillar are set to maintain a balanced LDRD-DR portfolio in support of the Laboratory’s capability goals. Priorities may include not just strategic capabilities, but also mission challenges requiring new and innovative approaches. Priority areas for each capability pillar (previously named “Focus Areas”) are outlined below. Based on these priorities, staff submit proposals for peer review in a two-stage process.

Note: In FY20, the Capability Pillars grew from four to six. Beginning with proposal calls released in FY21, LDRD will align with the sixth Pillar, namely “Weapons Systems.”

Capability Pillars and FY20 Directed Research Priorities

				
Information Science and Technology	Materials for the Future	Science of Signatures	Nuclear and Particle Futures	Complex Systems
Novel Computing Architecture and Algorithms High-Performance Data Analytics Convergence of Computational and Data Science	Advanced Manufacturing Quantum Materials Resilient Materials with Controlled Degradation Mesoscale Evolution in Extreme Environments	National Security and Threat Surveillance Adaptive Sensing Systems	Nuclear Reactors High Intensity Accelerators Mix and Transport Quantum Chromodynamics (QCD) Plutonium Understanding Multi-Messenger Astrophysics	Chemical Systems Subsurface Systems Biological Systems Space Systems and Impacts



Exploratory Research

In FY20, LDRD funded 173 ER projects, investing 33% of the program’s research funds. (These included 44 new starts based on the regular competitive call, with similar numbers continuing from FY18 and FY19, and the short-term projects discussed in the reserve section of this report.)

The ER component is focused on building technical staff competencies in key strategic disciplines that ready the Lab to address current and future national missions. Initiated by technical staff from across the Laboratory, ER projects explore highly innovative ideas in Technical Categories that underpin Laboratory missions (see below). ER projects are funded up to \$345K per year for three years.

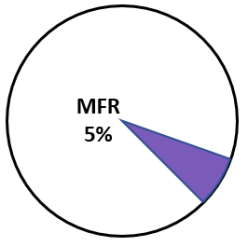
Exploratory Research is the most important channel for purely bottom-up creativity at the Laboratory. Division endorsements are not required for ER proposals; instead, this component of the program is operated as an open and competitive path for every staff member to pursue funding for his/her leading-edge idea. While some ER technical work may have a less direct tie to Laboratory missions, the technical capability underpinning the work must be directly relevant to one or more Laboratory missions.

In FY20, LDRD made improvements for the ER selection process via an “Exploratory Research Refresh.” The ER Refresh was coordinated by the LDRD Deputy Program Director, and the objective was to assess the current state of LDRD ER and recommend improvements, both strategic and process-focused. The ER Refresh committee recommended several changes, including: an Applied Research track that runs through all the ER Technical Categories, aligning applied research with the technical discipline that it draws upon and supports; adjustment of the ER Technical Categories, balancing across the breadth of the Laboratory’s disciplines of expertise; addition of “Seedling” ER projects, increasing acceptance of high-risk proposals with a high degree of innovation and potential to transform the technical field; structural changes to the pre-proposal review, reducing and leveling the burden of the review process; and additional ER review process adjustments, improving the quality of technical peer review. Laboratory senior leadership reviewed the Committee’s recommendations in FY20, and LDRD will pilot and/or implement improvements in FY21 (which will impact projects starting in FY22 and mid-year FY21).

Investments in Exploratory Research Strengthen Lab Capabilities via Technical Categories

- Atomic, Molecular, Quantum, and Optical Sciences (AMQOS)
- Biological Sciences (BIOS)
- Chemical Sciences (CHEM)
- Computational and Numerical Methods (CNM)
- Computer Science, Mathematics, and Data Science (CMD)
- Defects and Interfaces in Materials (DIM)
- Earth, Planetary and Space Sciences (EPS)
- Emergent Phenomena in Materials Functionality (EPM)
- Engineering Applications (ENG)
- High-Energy Density, Plasma, & Fluid Physics (HPF)
- Measurement Science, Instruments & Diagnostics (MID)
- Nuclear & Particle Physics, Astrophysics & Cosmology (NPAC)

Note: As part of the Exploratory Research Refresh, these categories have evolved for proposals solicited during FY21.



Mission Foundation Research

In FY20, LDRD funded 21 MFR projects, investing 4% of the program’s research funds.

MFR is an intentional investment in applied science and engineering relevant to national security missions. The component was initiated in FY17 to address mission needs in the technology readiness level (TRL) 3-5 regime. Proposals must respond to “mission problem statements” reflective of mission needs across the Lab as defined in the Lab Agenda. MFR projects are typically funded at \$160K over 8 months (Phase 1), with an additional \$700K awarded over 16 months for projects selected to continue into Phase 2.

In FY20, the phase 2 down-selection was postponed by approximately 2 ½ months compared to the original plan because of delays in experimental and classified work caused by the Coronavirus (COVID-19) outbreak. The down-selection was complete by the close of FY20. See the table on the next page.



Figure: Marisa Monreal’s (C-IIAC) MFR project concluded in FY20 – “A Multidisciplinary Approach to Advance Our Understanding of Actinide-Bearing Molten Salt Systems.” The project addressed Lab Agenda Objective 2.5 and established multiple new actinide-molten salt capabilities used to collect thermophysical property, chemical property, and modeling and simulation data. These capabilities were successfully integrated, and new insights were gained into these systems.

FY20 Mission Foundation Research Projects

Advanced Manufacturing and Characterization of non-SNM Nuclear Explosive Package Materials and Components

Title	Principal Investigator (Org)
*Modernizing Detonator Production and Inspection: Robotics meets Additive and Digital Manufacturing	Alexandria Marchi (MPA-11)
*Integrating Additive Manufacturing and Investment Casting for Complex Metal Architectures with Predictable Mechanics	Matthew Lee (MST-7)
*Special Carbide for Weapon Applications	David Jablonski (XTD-PRI)
*The Use of Additive Manufacturing of High Explosives and its Application to Weapon Safety	Von Whitley (XTD-SS)
*Rust, Dust, and a Passive Future - Resilient Actinide Materials	Samantha Lawrence (SIGMA-2)
*How can the granular defects of additive manufacturing be evaluated?	Carly Donahue (EES-17)
*In-Situ Ultrasound Grain Refinement in Electron Beam Additive Manufacturing for Improvement of High Strain-Rate Properties	Daniel Javernick (SIGMA-2)

Agile and Efficient Nuclear Manufacturing

Glovebox Diagnostics to Support Pu Cleaning Operations	Daniel Kelly (C-CDE)
*Understanding Homogenization Kinetics of As-Cast Plutonium Alloys to Improve Manufacturing of Weapons Components	Jeremy Mitchell (MST-16)
*Toward Automated Interpretation of Large, High Resolution Computed Tomography Volumes	Christopher Stull (E-6)
Solvent Anode Development for ER and EMIS	Christopher Leibman (MPA-11)
Revolutionary Separations for Efficient and Cost-Effective Am-241 Production	George Goff (MPA-11)

Materials and Methods for High Performance Accelerators

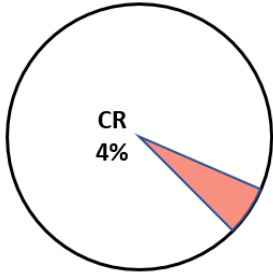
SRF Cavities: Looking Beyond Niobium	Evgenya Simakov (AOT-AE)
*Prompt, Photogated H- Source	Rodney Mccrady (AOT-AE)

Nuclear Verification: Negotiated Verification of a Halted or Dismantled Nuclear Program

Predictive Science for Inverse Problems in Non-proliferation	Thomas Burr (CCS-6)
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Tools to Leverage Real-time Data Feeds for Energy Security Applications

Non-Rigid Structure from Motion for Estimating Full-Field, High-Resolution 3D Vibration Mode Shapes from Multiple Moving Imagers for Off-Shore Windturbines	David Mascarenas (NSEC)
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Centers Research

In FY20, LDRD funded 8 CR projects, investing 4% of the program’s research funds.

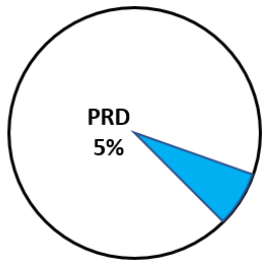
To infuse new ideas and people into the Laboratory, LDRD has made a commitment to partner with the Lab’s “Strategic Centers.” The CR component is focused on developing the nation’s next-generation workforce and leadership talent and to serving as an incubator for the introduction of emerging ST&E into DOE and NNSA missions. CR projects are typically funded up to three years and single-year per-project funding in FY20 ranges from approximately \$400K-\$1,700K.

The Centers are organized under the National Security Education Center (NSEC), which supports a broad spectrum of interdisciplinary science that underpins the Lab’s mission in national security. Collaborations established through the Centers provide Lab programs with new ideas, people, and contacts both inside and outside the Lab. For example, collaborative work with universities fosters top-quality research at the Lab in the more basic or fundamental aspects of fields that map into existing and/or emerging mission areas of the Laboratory. The Centers also introduce students and postdocs to the scientific interests of the Laboratory. The Centers nucleate new research areas at the interface between emerging frontiers in the scientific community and the Laboratory’s national security mission and are instrumental in anticipating future needs.

LDRD funds the Centers Rapid Response research and development program that supports short-term, rapid-turnaround high-risk ideas or feasibility studies. Three of the Centers have formal postdoctoral programs funded through LDRD, targeting strategic areas where new staff members are recruited at the PhD level.



Former Seaborg postdoctoral fellow Dr. Sarah Hernandez, partially funded by LDRD, performs actinide research in the Nuclear Materials Science (MST-16) group. Consistently, over half the postdocs at the Laboratory are funded at least 10% by LDRD. Hernandez will be the principal investigator on a LDRD Director’s Initiative starting in FY21.



Postdoctoral Research and Development

In FY20, LDRD funded 80 PRD projects, investing 5% of the program’s research funds.

The PRD component of the LDRD program ensures the vitality of the Laboratory by recruiting early career researchers. Through this component, LDRD funds Postdoctoral Fellows to work under the mentorship of PIs on highly innovative projects.

PRD projects are funded under two appointment types intended to represent the most promising among the Laboratory postdoc population—Director’s Postdoctoral Fellows and Distinguished Postdoctoral Fellows. Distinguished Fellows are supported at a higher salary and typically show evidence of providing a new approach or insight to a major problem that will likely have a major impact in their research field. To recognize their role as future science and technology leaders, Distinguished Fellows are named after some of the greatest leaders of the Laboratory’s past, such as Los Alamos Medal laureate Darleane Christian Hoffman.

In FY20, LDRD supported 66 Director’s (2 years, extendable to 3) and 14 Distinguished (3 years) Fellows. The LDRD program encourages conversion to staff by continuing the PRD project, post-conversion, until its originally planned end date.

LDRD also encourages collaboration between postdocs and Laboratory staff. More postdocs are hired through DR and ER projects than directly through PRD appointments. Counting both avenues, the LDRD program supported 55% of the 655 postdocs employed at the Laboratory for at least part of FY20.

LDRD Researchers Receive 2020 Postdoctoral Distinguished Performance Awards

The Laboratory established the Postdoctoral Distinguished Performance Awards to honor outstanding postdoc achievements that significantly impact the Laboratory’s scientific efforts and status in the scientific community.



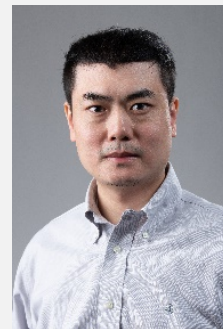
Derrick Kaseman

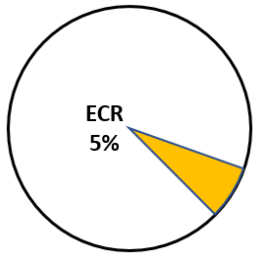
Previously a Director’s Postdoctoral Fellow, Kaseman is now a staff member in the Bioenergy and Biome Sciences (B-11) group. In addition to the Postdoctoral Distinguished Performance Award, Kaseman was also awarded the FY20 Postdoctoral Publication Prize in Engineering Science for his LDRD-funded work, "Design and Implementation of a J-Coupled Spectrometer for Multidimensional Structure and Relaxation Detection at Low Magnetic Fields."



Thuy-Ai (Bi) Nguyen Nguyen participated on an LDRD Exploratory Research project early in her career and is now a staff member in the High Explosives and Technology (Q-5) group.

Bin Yan Yan participated on an LDRD Directed Research project early in his career and is now a staff member in the Physics of Condensed Matter and Complex Systems (T-4) group.





Early Career Research

In FY20, LDRD funded 51 ECR projects, investing 5% of the program’s research funds.

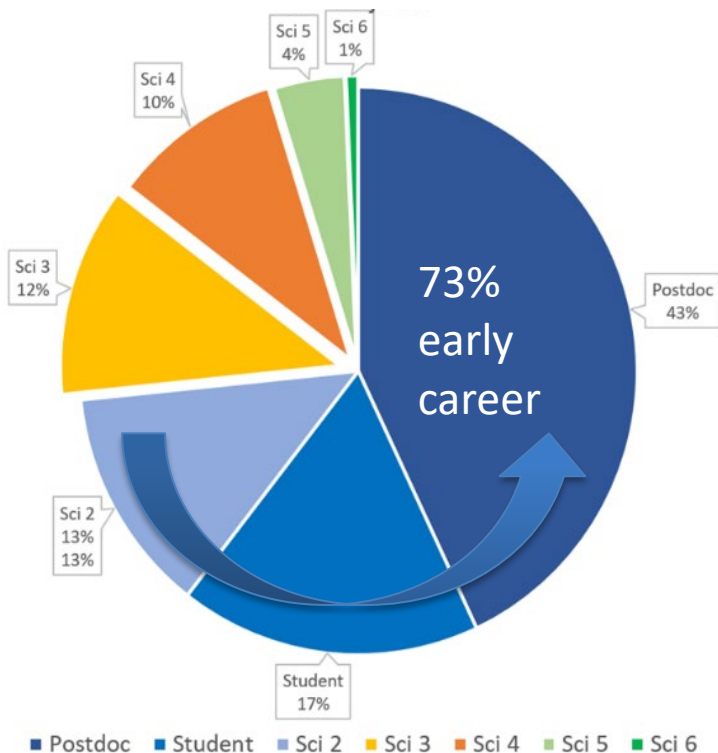
The ECR component of the LDRD program is designed to strengthen the Laboratory’s scientific workforce by providing support to exceptional staff members during their crucial early career years. The intent is to support the development of early career researchers, aiding in the transition from postdoc or student to full-time staff member, and to stimulate research in disciplines supported by the LDRD program.

In order to keep up with the modest increases in the cost of doing business, Early Career Research projects that start in FY21 will be funded at \$225K per year for two years. Ongoing projects that started in FY20 are funded at \$218K per year and those that started in FY19 are funded at \$208K per year.

LDRD has responded to the steady demand for early career support across the Laboratory in recent years, by growing its commitment to this component. The FY20 investment in ECR included 18 new starts, similar to FY18 and FY19 but double the previous year.

Early Career Research PIs must have received their highest degree within the last 10 years and been hired as a Laboratory technical staff member no more than three years prior to the call. Individuals with limited-term appointments are eligible; however, an Associate Level Directorate endorsement confirming the organization’s intent that the proposer will make a long-term contribution to the Laboratory must be submitted to LDRD.

LDRD Invests Heavily in Early Career Staff Across All Components

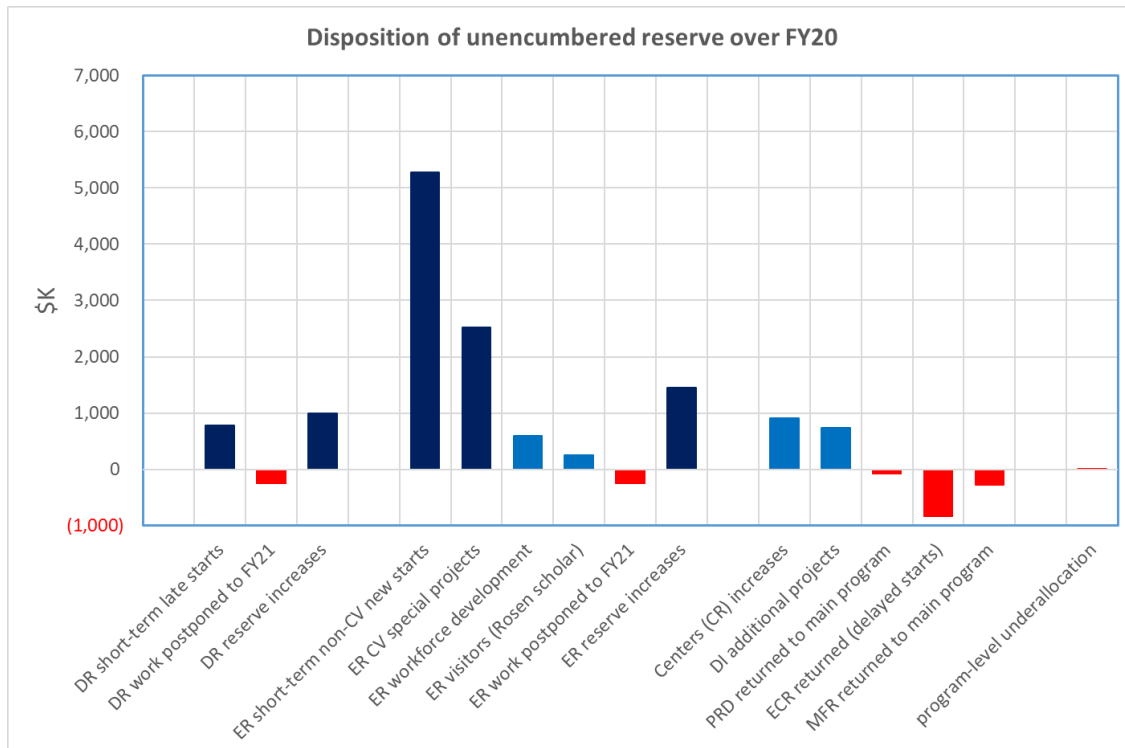


Hours charged to LDRD Projects

In a recent analysis, LDRD found early career researchers (in this case defined as postdocs, students, and Scientist/R&D Engineer 2) contribute the majority of hours to LDRD projects. LDRD is essential to retaining this critical demographic. (Data current though FY19.)

Reserve/Special Calls

Not all of the LDRD budget is allocated to individual projects at the beginning of the fiscal year. Some is set aside for planned new starts based on calls for the PRD, ECR, DI, and MFR components; and some is unencumbered, available for timely opportunities as the year unrolls. At the beginning of FY20, the unencumbered reserve was \$11.83M.



The LDRD Program Office improved the process for tracking reserve funding in FY20. The office increased the level of granularity of how “reserve” is defined and created a tagging schema that distinguishes various types of reserve allocations. Based on this tracking, the figure above shows how the reserve was allocated.

The columns in red indicate givebacks to reserve. These include PRD, ECR, and MFR, which did not start quite as much work as anticipated at the beginning of the year, and some specific moves of budget from FY20 and FY21 for DR and ER, caused by COVID impacts on execution.

The items in dark blue are investments made in response to Q1 and Q2 reserve calls to the Associate Laboratory Directors. Although these were not open calls, every proposal received peer review using the same criteria and standards as the competitive LDRD calls. Some of these investments resulted in a budget increase for a previously approved project; others were new projects concurred by the Site Office. Both the 29 new projects and the budget increases were short-term, ending at the end of FY20. Two of the new projects were categorized as DR because their ideas derived from a FY20 DR proposal.

Other mid-year investments (light blue columns) included two projects associated with strategic hires (workforce development), a visiting scholar, expansion of the Centers Rapid Response work, and additional Director’s Initiative starts.

LDRD's rapid response to COVID-19

A special initiative funded from reserve (CV special projects) was a mid-year call for R&D relevant to COVID and future pandemics (this was COVID-related R&D, rather than mitigation of COVID impacts on projects). LDRD reserve funding helped position the Laboratory to respond quickly to the Coronavirus (COVID-19) pandemic. Furthermore, these projects demonstrate how LDRD may be used to address Strategic Challenge #3: Deter and defend against threats in multiple domains (see the LDRD [Strategic Framework](#)).

The special call was released in March and intended to address gaps in understanding and responding to the outbreak. The focus areas for the call were: (1) therapeutics/vaccines, (2) diagnostics, and (3) decision support and infrastructure management, including disease modeling and epidemiology.

The quality of proposals submitted was outstanding. 42 proposals were received and 17 projects were selected for funding, for an approximate total of \$2.5M. All proposals received thorough peer review and selected projects started just two weeks from the proposal deadline (April 13, 2020). These funded projects ran through the end of FY20. An additional \$309K was allocated in FY20 to 4 projects with COVID-related increased scope of work.

Results of these projects are significant, including the timely distribution of information to the public when it was needed most. For example, a study published by principal Investigator Bette Korber in BioRxivs received over 200,000 downloads of the preprint (published April 30), by far a BioRxivs record (Korber, 20200706ER). The projects selected through the COVID call published 16 peer-reviewed articles by the close of FY20. In addition to peer-reviewed publications, these projects distributed information via public-facing web sites. For example, one project (Osthus, 20200700ER) developed and deployed a coronavirus forecasting model on the web within two weeks of receiving funding, providing valuable information to public health officials and the public at-large. At its peak, the website was getting 20 thousand visits a week. The forecasts on the website are being used to support the United States Centers for Disease Control and Prevention (CDC) and the New Mexico Department of Health (DOH).

Additional outcomes of LDRD-funded COVID research include:

- Discovery of misleading reports on spread patterns and speculations on the origin of Severe Acute Respiratory Syndrome-Coronavirus 2 (SARS-CoV-2) (Leitner, 20200694ER)
- Development of an analysis procedure that uses genetic sequence virus data, revealing information such as patterns of spread (Goldberg, 20200711ER)
- Invention of a “cough machine” that sprays fluorescent dye for the purpose of gaining an understanding of how materials might work when used as a mask (Ham, 20200720ER)
- Design of an assay that simultaneously detects multiple pathogens (Gans, 20200732)

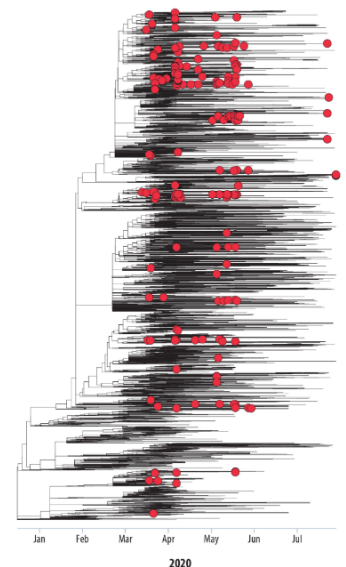


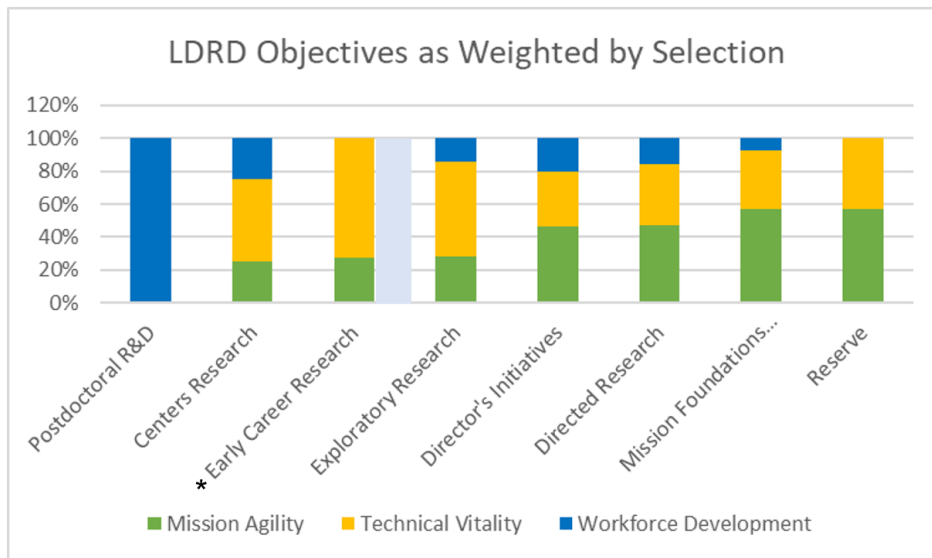
Image caption: By tracing what mutations show about the relatedness of infections, i.e., the phylogenetics—a capability Los Alamos previously advanced to address the evolution of HIV infections—LDRD researchers can help identify how and when the virus traveled from one region to another. In this model, tight groupings of red circles suggest clusters of New Mexico infections with a common source. However, the large number of New Mexico cases widely separated on this figure suggest a great many introductions arriving at different times. [Read more](#)>>>

LDRD Objectives Across the Portfolio

LDRD strives for a portfolio that reflects all three LDRD objectives—Mission Agility, Technical Vitality, and Workforce Development. The balance between technical vitality and mission relevance has evolved over the last few years; and, considering the whole LDRD portfolio, mission relevance has a bit more weight than previous years. LDRD has also added explicit consideration of workforce development to proposal and appraisal criteria.

The LDRD Program Office puts thoughtful consideration into how the weighting of selection criteria for each component addresses the three LDRD objectives. The scoring matrix for each component states how the criteria are weighted.

Share of Selection Criteria
Each component also evaluates research approach (not shown here).



Data current as of 2/19/20




* ECR projects are largely focused on workforce development, which is thus not an explicit criterion. The criteria for selection are divided between mission agility and technical vitality.

Program Value

Congress established the Laboratory Directed Research and Development (LDRD) program at the Department of Energy (DOE) national laboratories in 1991 to foster excellence in science and technology and to ensure the laboratories are technically vital and prepared to meet today's needs and tomorrow's challenges. LDRD achieves this by supporting high-risk, potentially high-payoff research and development. At Los Alamos, the LDRD program provides the most significant resource for internally directed scientific and technical investments.

The LDRD program is a key resource for addressing the science and technology goals of the Laboratory, as well as enhancing the scientific capabilities of Laboratory staff. Through careful investment of LDRD funds, the Laboratory builds its reputation, recruits and retains excellent scientists and engineers, and prepares to meet evolving national needs.

The programs' objectives are clear and crucial: Mission Agility, Technical Vitality, and Workforce Development.

<p>Mission Agility</p>  <p>Enable agile responses to national security challenges.</p>	<p>Technical Vitality</p>  <p>Advance the frontiers of science, technology, and engineering.</p>	<p>Workforce Development</p>  <p>Attract, retain, and develop tomorrow's technical workforce.</p>
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FY 2020 LDRD Program at-a-glance

\$147M

Total Program Cost

398

Total Number LDRD Projects

179

New LDRD Projects in 2020

Although LDRD costs are only a small portion of the Laboratory's base (6%), LDRD yields well over its share of postdoc conversions, publications, patents, and technical awards.

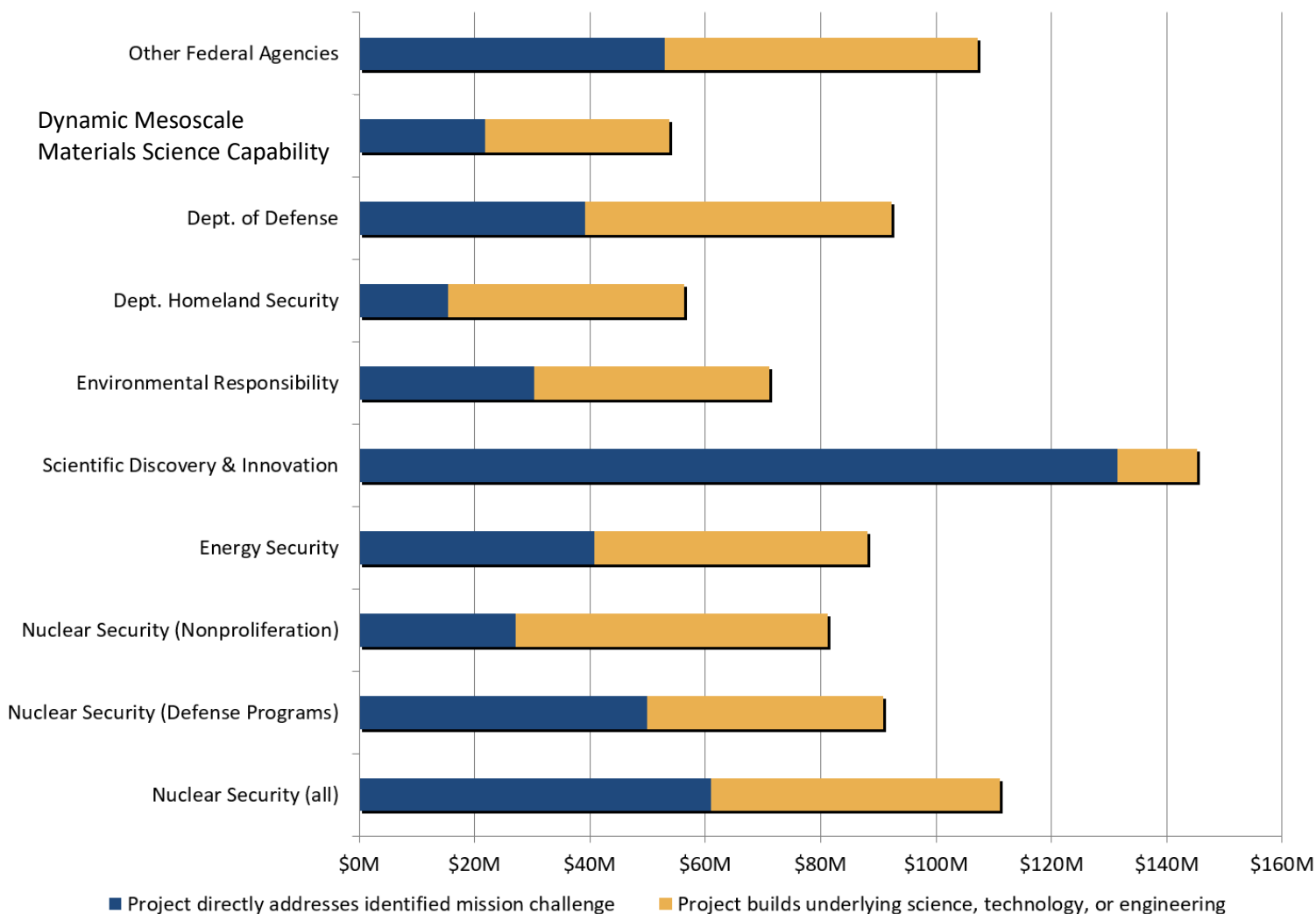
LDRD-supported Postdocs	55%	363 of 655 postdocs at Los Alamos
LDRD-supported Postdoc to Staff Conversions	47%	35 of 75 conversions at Los Alamos
Peer-reviewed Publications	34%	678 of 1,971 publications at Los Alamos
U.S. Patents Issued	41%	19 of 46 patents at Los Alamos
R&D 100 Awards	75%	6 of 8 R&D 100 awards at Los Alamos



Mission Relevance

Mission relevance is one of the most important criteria in the evaluation of the LDRD program, as well as a potential LDRD project. It is carefully considered in project selection and tracked annually through the data sheet process. Many of the technologies that put Los Alamos on the map have deep roots in LDRD and are valuable to DOE and NNSA mission areas of nuclear security, energy security, environmental remediation, and scientific discovery and innovation. LDRD work also benefits the national security missions of the Department of Homeland Security, the Department of Defense, and other Federal agencies. As a result, the scientific advances and technology innovations from LDRD provide multiple benefits to all Los Alamos stakeholders, consistent with Congressional intent and the Laboratory's scientific strategy.

Mission Impact of FY20 LDRD Portfolio (\$M)



First and foremost, Los Alamos LDRD projects are required to address one or more of the DOE or NNSA mission areas. The sum of the total LDRD investment in relevant missions is far greater than the annual LDRD budget; investment in one project often contributes to and impacts multiple missions.

Due to the basic science nature of LDRD, the work often proves relevant to several missions and agencies. LDRD data sheets include an analysis of mission relevance in which the PI indicates direct, underlying and clearly related, or no relevance to federal agency missions, nuclear security and national defense, energy security, environmental stewardship, and areas of scientific discovery and innovation.



Dr Xuan-Min Shao
Los Alamos National Laboratory

For example, PI Xuan-Min Shao is exploring the connection between the intense electromagnetic pulse and energetic particle emissions from lightning discharges in order to better understand the corresponding signals in atmospheric nuclear explosions. While there have been recent advances in lightning research, Shao and his team are digging into the many fundamental questions that remain unanswered and are of interest not only to science programs, but also to defense and nuclear nonproliferation programs. The signatures under study are unwanted background interference for systems that monitor nuclear emissions. Better understanding these signatures and the underlying physics is critically important to reduce possible false alarms and to validate simulations of the United States Prompt Diagnostic System for prompt nuclear weapon performance information. (20170179ER, “High Energy Lightning: Understanding Relations between Energetic Particle and Lightning Discharges in Thunderclouds.”)

[Read more>>>](#)
[Read more>>>](#)

(1663 magazine)
(Scientia)

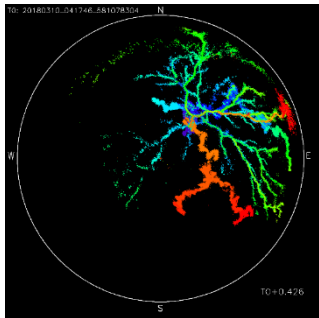
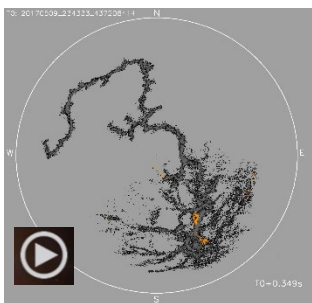


Figure: LDRD researcher Xuan-Min Shao and his team obtained this lightning image with a radio frequency interferometer at the High-Altitude Water Cherenkov (HAWC) Gamma-Ray Observatory. The Los Alamos HAWC Observatory, designed to observe the most energetic objects in the known universe, is on a mountaintop and well-situated for observing lightning. This lightning lasted 0.43 seconds and the colors from violet to red indicate the time sequence of the lightning activity.



Colors from violet to red correspond to the lightning radio sources from its beginning to its end.



Video: Shao’s lightning detector compares phase differences between very-high-frequency radio signals received from spatially separated antennas to map lightning sources in sub-microsecond time resolution. This [video](#) illustrates the spatial and temporal development of a lightning discharge as it propagates over the course of 0.55 seconds. The orange dots in this video indicate the lightning sources in the current time frame.

The LDRD program responds to four national security challenges identified in the [Strategic Framework](#) (and derived from the 2018 Nuclear Posture Review). This highlight demonstrates how LDRD address Strategic Challenge # 2: *Protect against all weapons of mass destruction threats.*

Project Appraisals

The LDRD Program Office oversees formal appraisals of all second- and third-year projects (not including PRDs). A primary objective of the project appraisals is to assess progress and provide peer input to help PIs maintain the highest quality of work possible. The appraisals also help the LDRD Program Office monitor and manage the program portfolio.

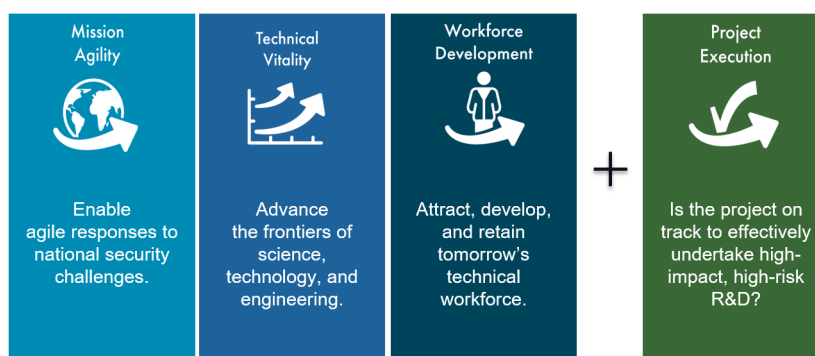
LDRD formal project appraisals in FY20 indicate a high level of productivity and excellence. The LDRD Program Director oversees the Exploratory Research (ER) appraisals in collaboration with the technical divisions. Projects were appraised according to criteria that map to the LDRD objectives: technical vitality, mission agility, workforce development, as well as a fourth criteria, namely, project execution. As of this report, 85 appraisals have been conducted and scores are currently available for 78 projects. The LDRD Program Director's overall impression of a high level of productivity and excellence (despite COVID challenges) is upheld by the appraisal scores, in which the weighted average is 4.26 ("excellent" on the standardized scoring theme), ER projects consistently contribute significantly to performance output measures. For example, in an analysis of LDRD's publication output from FY16 to FY19 ER projects yielded 29% of LDRD's peer-reviewed publications.

Directed research appraisals conducted in FY20 demonstrated a similar high level of productivity and excellence. DR projects are appraised every year of the project, with a half-day appraisal at the beginning of year 2, a shorter appraisal at the beginning of year 3, and a final appraisal after the project ends. As of the submission of this plan, 14 of 14 year 2 appraisals have been conducted, with an average score of 4.39 (or "excellent"). The average score rose to the "outstanding/excellent" range for year 3 appraisals (4.6), pointing to the efficacy of the appraisal process to help PIs maintain high quality work. The final appraisals for DR projects that end at the close of FY20 will take place in FY21.

Those few appraisals that are significantly less than "excellent" result in discussions with the project and line leadership, and, when needed, corrective action plans.

In addition to the formal project appraisals, LDRD regularly holds informal project visits, paying particular attention to reserve projects, projects just getting started, and projects in their last few months. The objective is to understand project accomplishments and any opportunities for improvement to the project or the LDRD program. A project visit takes the LDRD Program Director or Deputy into the field, typically to the PI's office or lab but this year into a WebEx conference, for a discussion of up to 90 minutes.

LDRD projects are appraised every year via criteria derived from the three LDRD objectives + Project Execution.



Performance Indicators: LDRD at LANL

This section presents both short and long-term performance indicators LDRD maintains to evaluate the success of LDRD projects and to inform planning activities at the Laboratory. Although LDRD costs are only a small portion of the Laboratory's base (6%), LDRD yields well over its share of intellectual property, postdoc conversions, publications, patents, and technical awards.

Intellectual Property

An indication of the cutting-edge nature of research funded by LDRD is the contribution the program makes to the Laboratory's intellectual property. Year after year, projects sponsored by LDRD achieve a disproportionately large percentage of the patents and copyrights issued for Los Alamos research.

U.S. Patents

Number of US patents issued in a given FY

LDRD supported: Patents issued that would not exist if not for initial work funded by LDRD

	FY16	FY17	FY18	FY19	FY20
LANL U.S. patents	88	43	51	53	46
LDRD supported	19	9	10	20	19
% due to LDRD	22%	21%	20%	38%	41%

Foreign Patents

In FY20, the first year LANL tracked foreign patent data, 39 foreign patents were granted and eight of those patents have LDRD roots. Each foreign patent maps to a U.S. patent granted in previous years. In other words, all patents granted outside the U.S. also have a patent granted in the U.S. There may be multiple foreign patents granted for the same invention.

Software Copyrights

Number of software copyrights created in a given FY

LDRD supported: Software copyrights issued that would not exist if not for initial work funded by LDRD

	FY17	FY18	FY19	FY20
LANL software copyrights	148	113	147	119
LDRD supported	21	19	16	39
% due to LDRD	14%	17%	11%	33%

Note: The majority of copyrights granted at LANL are software copyrights. Developing and exchanging software is a critical stepping stone in the collaborative efforts which drive the success of many projects. LANL has three primary software release types: open source (unrestricted release of source code via a publicly available repository); commercial/noncommercial licensing (controlled release of code to commercial entities, academic collaborators, or foreign government agencies); and government use only (controlled release of code to U.S. government agencies/contractors).

Invention Disclosures

Number of declarations and initial records of an invention (a new device, method, or process developed from study and experimentation)

LDRD supported: Disclosures issued that would not exist if not for initial work funded by LDRD


	FY16	FY17	FY18	FY19	FY20
LANL disclosures	133	117	109	118	115
LDRD supported	69	24	40	39	34
% due to LDRD	52%	21%	37%	33%	30%

Tech Snapshots


Los Alamos has identified a broad range of technologies that could enhance an existing product, define a new product, or launch a start-up. Our technologies have the potential to give your company a competitive edge in the market. Each are at different stages of development some ready to license and others looking for a partner to help mature into a disruptive application. Check out the Technology Snapshot platform to explore the wide variety of technologies available.

“Tech Snapshots” on many of these technologies can be found on the Richard P. Feynman Center for Innovation [web site](#).


Search




Advanced Materials




Biology




Chemistry




Cyber Security




Data Analytics




Earth and Environmental




Infrastructure Manufacturing




Software



Nuclear



Sensors



Space

Peer-reviewed Publications

The LDRD program produces a large volume of high-quality scientific contributions relative to its portion of the Laboratory's budget. The numerous publications made possible with LDRD funding help the Laboratory maintain a strong presence and scientific reputation in the broader scientific community. In 2020, 34% of LANL peer-reviewed publications have roots in LDRD. The quality of these publications is evidenced by the frequency they were cited where the LDRD percentage, 44% in FY20, has been rising in recent years.

Publications

Number of peer-reviewed publications

LDRD supported: Publications that would not exist if not for initial work funded by LDRD

	FY16	FY17	FY18	FY19	FY20
LANL publications	1,968	2,001*	2,100	2,066	1,971
LDRD supported	426	525*	613	714	678
% due to LDRD	22%	26%	29%	35%	34%

*FY17 data corrected 3/12/20. Percentage LDRD did not change.

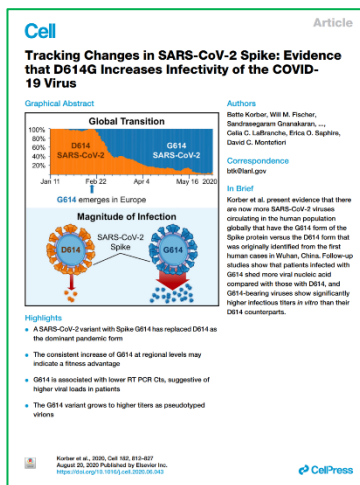
Citations

Number of citations of peer-reviewed publications

LDRD supported: Citations of publications that would not exist if not for initial work funded by LDRD

	FY16	FY17	FY18	FY19	FY20
LANL citations	45,120	34,316	29,161	16,565	8,848
LDRD supported	15,272	12,097	11,149	7,552	3,907
% due to LDRD	34%	35%	38%	46%	44%

Note: Citations are current as of 3/11/21 and drawn from Web of Science—a website that provides access to multiple databases that provide comprehensive citation data for many different academic disciplines. Originally produced by the Institute for Scientific Information, it is currently maintained by Clarivate Analytics.



This paper published by theoretical biologist and LDRD researcher Bette Korber was one of the five most highly cited papers at LANL in 2020.

Science and Engineering Talent Pipeline

In an increasingly competitive job market, LDRD remains an important vehicle for recruiting the brightest researchers to Los Alamos National Laboratory, where they become innovators and scientific leaders. LDRD is also instrumental in retaining new talent from the student and postdoc pool at the Laboratory.

Postdoctoral Researcher Support

Number of postdoctoral researchers working full- or part-time for the Laboratory
LDRD supported: Postdoctoral researchers charging at least 10% time to LDRD

	FY16	FY17	FY18	FY19	FY20
LANL Postdocs	501	497	556	632	655
LDRD supported >10%	272	263	281	376	363
% due to LDRD	54%	53%	51%	59%	55%

Note: Includes data on postdocs in FY20 from Sept. 30, 2019 to Sept. 27, 2020.

Postdoctoral Researcher Conversions

Number of conversions from postdoctoral researcher to a member of the staff
LDRD supported: Conversion of postdoctoral researchers who charged at least 10% time to LDRD in the fiscal year preceding the conversion

	FY16	FY17	FY18	FY19	FY20
LANL Conversions	80	69	81	87	75
LDRD supported >10%	47	37	37	39	35
% due to LDRD	59%	54%	46%	45%	47%

Note: Includes data on postdocs in FY20 from Sept. 30, 2019 to Sept. 27, 2020.

Students

There are many opportunities for students to play important supporting roles on LDRD projects. A student may serve as a Co-Investigator on any LDRD proposal. For example, it is common to see students funded on ER and DR projects. There are also opportunities for a student to work with an early career staff member on an Early Career Research project, where the early career staff member would serve as the PI and the student would serve a significant secondary role to that PI. Furthermore, the Centers have specific calls for student projects.

In FY20, 258 students worked at least 40 hours on LDRD projects.



Figure: LDRD fosters collaborations with universities in many ways. Pictured here is Cyler Conrad who was converted to a staff position at Los Alamos after graduating from the University of New Mexico in 2018 and continues to work as an adjunct assistant professor of Archaeology at the University of New Mexico (UNM). Conrad was selected in FY20 to lead an Exploratory Research project, “Long-lived Fauna as Tracers of Anthropogenic Radionuclides,” which will allow researchers to better map and understand nuclear events in the environment, their effects on animals, and what this could mean for humans.

Read more in the [University of New Mexico News](#).

The screenshot shows the UNM Newsroom website. At the top, there is a navigation bar with links for UNM A-Z, StudentInfo, FastInfo, myUNM, and Directory. Below this is a search bar and a list of news topics: About Us, News Topics, Schools and Colleges, and For News Media. The main content area features a news article with a large image of a tortoise. The article title is "UNM, LANL to study radioactive elements in tortoises". To the right of the title is a "Media Contact" section for Mary Beth King, with her phone number (505) 277-5754 and email mbuk2005@unm.edu. Below the title and image, there is a short paragraph: "Study will examine effects of nuclear events in environment, on animals and humans".

The Long-Term Impacts of LDRD Investments

The LDRD program is an investment in the nation’s future, ensuring mission support that is often realized after many years. This section highlights the longer-term (>5 year) impact of LDRD as a national asset. These performance indicators will be updated annually. As it is expected that the data may vary from year to year, long-term running totals will also be included and updated every 5 years.

Background

As part of a commitment to continuous improvement, representatives from each LDRD program at the NNSA laboratories regularly participate in a working group to share best practices and discuss strategies for tracking the long-term impact of LDRD investments. In FY20, the working group finalized a combination of common quantitative and qualitative long-term indicators, emphasizing a systematic approach. Additionally, the working group recognized that individual laboratories may choose to report other long-term indicators that fit their unique missions and capabilities.

Alignment with LDRD Objectives

The collective selection of indicators (both numerical and qualitative) illustrate the long-term payoffs/success of LDRD, with respect to all three LDRD objectives (Technical Vitality, Mission Agility, Workforce Development). Because indicators crosscut objectives, there is not an intent to provide a 1:1 mapping of indicators with objectives.

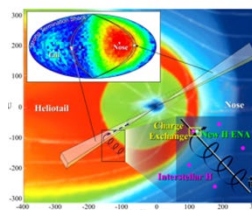
Importance of Qualitative Data

The difficulty of developing numerical indicators for success in R&D programs is widely recognized. The metrics working group was able to develop numerical success indicators for both Technical Vitality and Workforce Development. “Success stories” were found to be more flexible to capture the successes in Mission Agility, as well as aspects of the other two LDRD objectives that are not well-capture by numerical metrics.

Tracing impact back to LDRD

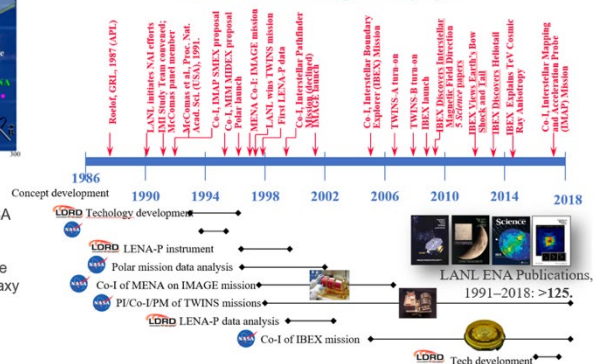
Throughout this section, you will see references to “LDRD roots.” There is often a lot of discussion with PIs about what it means for an accomplishment to have “LDRD roots.” A simple case would be if an idea for an invention arises during an LDRD project and work on the invention is completed during the period of LDRD investment. But R&D often does not advance on such a short timescale. In general, an accomplishment (invention, paper, capability, etc.) is determined to have LDRD roots if there are one or more LDRD projects without which the accomplishment would never have come into being. In other words, if one can identify an LDRD project that was critical to the accomplishment, then it is considered to have “roots” in that LDRD project. Other relevant definitions for the metrics shared are included in the sections to follow.

LDRD Advances Nuclear Security Capability
Energetic neutral atom (ENA) imaging puts Los Alamos at the forefront of global space awareness.



Using LANL’s High Energy Neutral Atom Imager, the NASA Interstellar Boundary Explorer (IBEX) mission provided important information about the origin and evolution of our galaxy and solar system as well as other stellar environments.

LDRD investments over 30+ years demonstrate long-term payoff



Long-term Indicators

Professional Fellows (American Physical Society)

One relevant indicator of advancement and leadership in a ST&E field is the election of individuals as fellows of professional societies. This indicator reflects success for both the individual researcher and the laboratory as a whole. American Physical Society (APS) Fellows were selected as the exemplar due to the important linkage of physicists with NNSA’s core stockpile stewardship mission. Furthermore, APS Fellowship is awarded based on scientific merit and impact over an extended period of time. (In contrast, some professional societies may also award fellow status based on service to the society.)

In FY20, five of the six LANL APS Fellowships were awarded to researchers with roots in LDRD. While there is sometimes minor fluctuation from year to year, multi-year analyses consistently reflect a high majority of APS Fellows with prior LDRD experience. At LANL, 63 of the 68 researchers who have been awarded APS fellowships in the last ten years have prior experience with LDRD.

History of APS Fellows at Los Alamos National Laboratory

	Single-Year Statistics			Multi-Year Statistics		
	FY18	FY19	FY20	FY11-15 (5 years)	FY16-20 (5 years)	FY11-20* (10 years)
Total awards	4	5	6	38	30	68
Awards with LDRD roots	4	4	5	35	28	63
% with LDRD roots	100%	80%	83%	92%	93%	93%
Average years from first LDRD experience	16.25	10.00	12.20	8.94	11.82	10.26

*Initial year to date: Each Laboratory has chosen the appropriate lookback period that will ensure data integrity.

Why this matters

The fact that so many APS Fellows at the Laboratory have prior LDRD experience is a testament to LDRD nurturing their careers (workforce development) and the technical vitality of the Laboratory. LDRD draws high caliber talent into the Laboratory and considers the commitment to continue to develop these researchers to be crucial to the future success of both those researchers and the Laboratory.

“Recognition of their accomplishments by the American Physical Society demonstrates the vibrant engagement that the Laboratory’s physicists have with the external scientific community and their contributions to physics research.” – John Sarrao, Deputy Director for Science, Technology & Engineering

Five of Six LANL Researchers Elected 2020 APS Fellows Have LDRD Experience

Six LANL scientists were elected Fellows of the American Physical Society (APS), chosen for their exceptional contributions to the physics enterprise. Fewer than one half of one percent of APS members are elected as fellows each year. Notably, five of the six have received LDRD funding. On average, APS fellows win the award 10 years following their first LDRD experience.



Luis Chacon was nominated by the APS Division of Computational Physics for “seminal contributions in the development of novel algorithms for fluid and kinetic plasma simulation, enabling breakthroughs in the understanding of fast magnetic reconnection, and the impact of kinetic effects in strong plasma shocks and in ICF implosions.” Chacon joined the Theoretical Division at Los Alamos as a Director’s funded Postdoctoral Fellow in 2000, and became a staff member in 2002. His work with LDRD began in 2004 when Chacon was the PI on an Exploratory Research project. He is now a senior scientist of international stature in the Applied Mathematics and Plasma Physics group in the Theoretical Division at Los Alamos National Laboratory. (First LDRD experience 2004)



Andrea Favalli was nominated by the APS Forum on Physics and Society for “outstanding application of the methods and underlying science of nuclear physics to the crucial issues of nuclear safeguards and security.” Favalli joined the Nuclear Engineering and Nonproliferation division at Los Alamos in 2009 and he became an investigator on his first LDRD project in 2013. His work has focused on nondestructive assay (NDA) of nuclear materials, ranging from new analytical approaches to experimental work. He has contributed to designing and implementing NDA measurement systems for nuclear material accountancy for nonproliferation throughout the world. (First LDRD experience 2013)



Ralph Menikoff was nominated by the APS Topical Group on Shock Compression of Condensed Matter for “pioneering contributions to the fundamental understanding of materials under extreme conditions, including the physics and modeling of shock waves, detonation waves, equations of state, and reactive burn models for chemical explosives.” Menikoff came to the Lab in 1974 as a postdoc in the particle physics group. Two years later he became a staff member and joined the Detonation Physics group when it was first formed. He has been in Theoretical division for his entire career, and is currently in the Physics and Chemistry of Materials group. His work with LDRD started in 2007 when he became an investigator on a Directed Research project. (First LDRD experience 2007)



Nikolai Sinitsyn was nominated by the APS Division of Condensed Matter Physics for “outstanding and original contributions to spin noise spectroscopy, anomalous Hall effect, geometric phases, multistate Landau-Zener models, and many-body nonadiabatic transitions.” Sinitsyn held a post-doctoral fellowship at Los Alamos from 2007 to 2009, and worked as an investigator on an LDRD Exploratory research project during this time. Sinitsyn joined the Lab as technical staff member in Theoretical division in 2010. (First LDRD experience 2008)



Blas Uberuaga was nominated by the APS Division of Computational Physics for “the development of accelerated molecular dynamics methods and their application to the understanding of radiation effects in materials, including the amorphization resistance of complex oxides, and the discovery of a new mechanism for point defect recovery at interfaces.” Uberuaga first came to the Lab as a postdoc in 2001, and has been a staff scientist in the Materials Science and Technology division since 2004. His work with LDRD began in 2007 when Chacon was an investigator on an Exploratory Research project. (First LDRD experience 2007)

R&D 100 Awards

Another relevant indicator of advancement and leadership in a ST&E field is R&D 100 Awards. The prestigious “Oscars of Invention” honor the latest and best innovations and identify the top technology products of the past year. The LDRD Program offices at each site often partner with sister organizations, such as the Intellectual Property Office and Public Affairs, to track whether R&D 100 winners (whether in the standard category or special awards) have “LDRD roots.” Because of the long development time from idea (LDRD) to practical implementation (R&D100 Award candidate) the staff who work on something that wins an R&D 100 Award may not be the same staff who worked on the original R&D. Each site’s LDRD Program Offices engage in an extensive interview process to uncover the details of how the LDRD work led to the celebrated invention.

In FY20, six of the eight R&D100 Awards received by LANL have roots in LDRD. While there is sometimes minor fluctuation from year to year, multi-year analyses consistently reflect a high majority of R&D100 winners with prior LDRD experience. At LANL, 32 of the 53 R&D100 awards given to LANL in the last ten years have roots in LDRD. On average, awardees in 2020 with LDRD support trace the initial LDRD investment to five years prior.

History of R&D 100 Awards at Los Alamos National Laboratory

	Single-Year Statistics			Multi-Year Statistics		
	FY18	FY19	FY20	FY11-15 (5 years)	FY16-20 (5 years)	FY11-20* (10 years)
Total awards	8	9	8	14	39	53
Awards with LDRD roots	4	5	6	9	23	32
% with LDRD roots	50%	56%	75%	64%	59%	60%
**Average years from first LDRD investment	2	6	5			

*Year to date: Each Laboratory has chosen the appropriate lookback period that will ensure data integrity.

**Los Alamos began tracking the years since first LDRD investment comprehensively in 2018.

Why does this matter?

LDRD enables scientists and engineers to advance fundamental science with many possible applications. In this way, LDRD is the spark that sets many achievements in motion. Identifying the LDRD roots in R&D100 winners reflects the maturation of a concept from early R&D to an innovation with practical utility. The Laboratory technologies recognized by R&D 100 Awards often benefit many facets of society at-large.



Since 1978 Los Alamos has won more than 170 of the prestigious R&D 100 Awards, approximately 4% of the total ever awarded. In 2020, it took eight and six of the awards have roots in LDRD. These awards represent the program’s investments in science, engineering, and technology impacting the broader scientific community. Below are the six 2020 winners with roots in LDRD.

AMANZI Advanced Terrestrial Simulator

Principal Investigator: David Moulton



Amanzi-ATS is an open-source software that includes the most complete suite of surface/subsurface physical processes to model complex environmental systems across multiple scales. Amanzi-ATS has been used to analyze pristine local watersheds, wildfire impact on watersheds, subsurface contaminant transport at legacy waste sites, the effect of a warming climate on the Arctic tundra, and groundwater in fractured porous media. This work has benefited

from timely and critical support from LDRD. Related LDRD projects include: Predicting Climate Impacts and Feedbacks in the Terrestrial Arctic (20120068DR); Critical Watersheds: Climate Change, Tipping Points, and Water Security Impacts (20150397DR); and Adaptation Science for Complex Natural-Engineered Systems (20180033DR).

Video link: <https://www.youtube.com/watch?v=mVibEU7npI0&feature=youtu.be>

Multi-Burn Solid Rocket

Principal Investigators: Nick Dallmann, Bryce Tappan, Mahlon Wilson



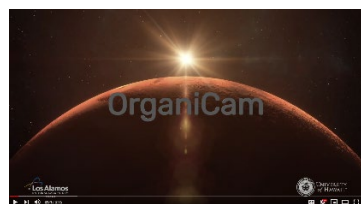
Solid rockets are high thrust, safe, scalable, and can be stored for long periods. However, they traditionally only provide a single burn per motor. The Multi-burn Solid Rocket is a revolutionary system providing multiple independent thrusts from a single solid rocket. This new capability could provide agile maneuverability for even the smallest and lowest cost satellites. The Earth’s orbital zones are an important natural resource. The Multi-burn Solid Rocket

could help protect this resource by enabling satellites to avoid orbital debris and to de-orbit at the end of life. This work is a direct outcome of a LDRD project, “ERIS: Electrolysis Rocket Ignition System” (20180382ER).

Video link: https://www.youtube.com/watch?v=RVQr2vEsIXU&feature=emb_log+o

OrganiCam

Principal Investigators: Roger Wiens and Patrick Gasda



OrganiCam is the first camera for noncontact, nondestructive biodetection in remote environments and space. It opens exciting frontiers in space exploration and the search for signs of life beyond the Earth. The compact laser-induced fluorescence imaging camera with Raman spectrometer could identify organic molecules and biosignatures in Martian caves, icy-moons, and asteroid surfaces.

OrganiCam’s robust design for extreme environments, portability, simple operation, and low power requirement build on the Lab’s 50+ years designing robotic instruments for space

applications. This work is a direct outcome of a LDRD project, “OrganiCam: A High-Sensitivity Radiation-Hardened Imaging Organic Detector For Space and Programmatic Applications” (20180244ER). It also benefited from a FY14 LDRD project, “Remote Raman-LIBS Spectroscopy (RLS) Signature Integration” (20140033DR).

Video link: <https://www.youtube.com/watch?v=DYUHAzaOKvM&feature=youtu.be>

QUIC-Fire

Principal Investigators: Rodman Linn



The Quic-Fire software is the first fast-running, laptop-capable, 3D fire-atmosphere feedback model for complex wildfire and prescribed fire scenarios. It simulates critical influences of 3D vegetation structure, variable winds, interaction between multiple fires, and complex topography at meter-scale spatial resolutions. QUIC-Fire transforms fire and fuel manager’s ability to assess risk, optimize fuel treatments, and plan prescribed burns to prevent catastrophic

wildfires. The modeling software QUIC was developed and funded through a FY15 LDRD project, "Critical Watersheds: Climate Change, Tipping Points, and Water Security Impacts" (20150397DR).

Video link: <https://www.youtube.com/watch?v=3uVhUXB4b84&feature=youtu.be>

Smart Microbial Cell Technology

Principal Investigator: Ramesh Jha



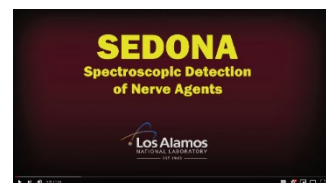
Biocatalysts are essential for food production, pharmaceuticals, specialty chemicals, renewable energy, and environmental cleanup. Current methods to find biocatalysts are slow. Smart Microbial Cell Technology selects rare mutations needed for biocatalyst optimization orders of magnitude faster than current screening methods. LDRD funded development of this technology through a reserve grant, "Genomics and Biomanufacturing" (20160656ER). Smart Microbial Cell Technology also

received a Silver Special Recognition Award for Market Disruptor-Services, which highlights any service from any category as one that forever changed the R&D industry or a particular vertical within the industry.

Video link: https://www.youtube.com/watch?v=_QueFOT2Yzk&feature=youtu.be

Spectroscopic Detection of Nerve Agents

Principal Investigator: Robert Williams



Spectroscopic Detection of Nerve Agents (SEDONA) is the only portable screener to accurately detect the chemical nerve agents in unopened bottles, providing results in seconds. Current airport detection system cannot scan for the threat of toxic organophosphorus nerve agents and insecticides. The SEDONA portable system screens *through* an unopened bottle using the principles of nuclear

magnetic resonance spectroscopy. SEDONA dramatically reduces the likelihood of a successful nerve agent attack at airports, government buildings, embassies, sporting events, concerts, and political rallies. The work draws on data originally generated in a LDRD project, "Fieldable Chemical Threat Mapping by Multi-modal Low Magnetic Field Nuclear Magnetic Resonance Signatures" (20170048DR).

Video link: <https://www.youtube.com/watch?v=CiJO1vGg9UY&feature=youtu.be>

Top 2%

A relevant indicator of career advancement in a ST&E field is the recognition of individuals as distinguished members of the technical staff. These staff members are named “Fellows” at LANL, Senior Scientists/Engineers at SNL, and Distinguished Members of the Technical Staff (DMTS) at LLNL. The shorthand name used here, “Top 2%,” comes from the intent at each laboratory to limit membership to the top 1% or 2% of scientific and technical staff. Typically nominated and screened by a committee, the Top 2% are recognized for something similar to a lifetime achievement award, in this case, for contribution to the Laboratory’s mission.

In FY20, all seven of the LANL staff awarded the Fellow recognition had prior experience with LDRD. While there is sometimes minor fluctuation from year to year, multi-year analyses consistently reflect a high majority of APS Fellows with prior LDRD experience. At LANL, 44 of the 49 researchers who have been awarded APS fellowships in the last ten years have prior experience with LDRD. Fellows typically gain LDRD experience early in their careers, with an average of about 13 years from their first LDRD experience to being named a Fellow.

History of Fellows at Los Alamos National Laboratory

	Single-Year Statistics			Multi-Year Statistics		
	FY18	FY19	FY20	FY11-15 (5 years)	FY16-20 (5 years)	FY11-20 (10 years)
Total awards	5	7	7	22	27	49
Awards with LDRD roots	4	6	7	19	25	44
% with LDRD roots	80%	86%	100%	86%	93%	90%
Average years from first LDRD experience	17.3	16.3	12.7	10.6	14.5	12.8

*Year to date: Each Laboratory has chosen the appropriate lookback period that will ensure data integrity.

Why does this matters?

Early involvement in LDRD has been found to have significant impact on career advancement, allowing participants unique opportunities to develop themselves and their ideas. Success in the national security enterprise depends on this world-class technical workforce.

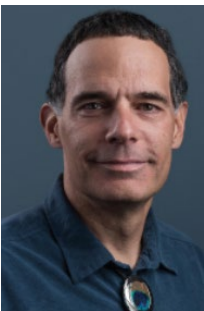
Seven of Seven Researchers Elected as 2020 Fellows Have LDRD Experience

Seven LANL scientists and engineers were elected as 2020 Laboratory Fellows. They represent top contributions made at the Laboratory and all seven have LDRD experience.



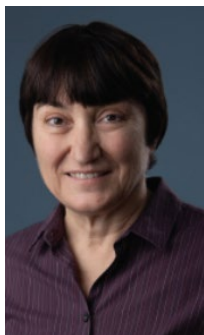
Tanmoy Bhattacharya, of Nuclear and Particle Physics, Astrophysics and Cosmology (T-2), works in the fields of Lattice Quantum Chromodynamics (QCD) for high-energy and nuclear physics, fundamentals of quantum mechanics, quantum computation, computational approaches to evolutionary biology and linguistics, data science, machine learning and vaccine development. Bhattacharya has made fundamental, important discoveries that have been widely employed and become a recognized authority nationally and internationally in the fields of lattice QCD, evolutionary linguistics and computational biology.

(First LDRD experience 1996)



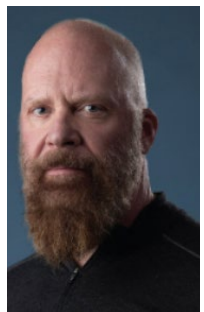
Christopher Fontes, of Materials and Physical Data (XCP-5), is an expert in relativistic atomic physics. He is a developer of the Los Alamos suite of atomic codes, which is considered to be a theoretical benchmark capability for plasma emission modeling. Fontes has sustained a high level of achievement and leadership in atomic and plasma physics. He is a Fellow of the American Physical Society and has made pioneering contributions to the understanding of atomic processes in plasmas and their application to a broad range of physics problems including nuclear fusion, laboratory experiment and astrophysics.

(First LDRD experience 2008)



Vania Jordanova, of Space Science and Applications (ISR-1), is an expert in space physics and space weather, which refers to the adverse impact of the dynamic space environment on human technological systems. Jordanova is a recognized international authority on geomagnetic storms, when vast amounts of energy is transferred from the solar wind into the near-Earth space environment (the magnetosphere).

(First LDRD experience 2006)



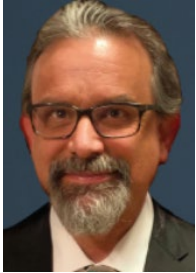
Thomas Leitner, of Theoretical Biology and Biophysics (T-6), is an expert in phylodynamics, the study of how epidemiological, immunological and evolutionary processes act and interact to shape viral phylogenies. Leitner is recognized for his contributions to the development of the field of phylodynamics, his pioneering work on exploiting phylogenetics to trace HIV evolution and epidemiology and the application of evolutionary biology to forensics. His work is recognized internationally, which has helped him attract many superb postdoctoral fellows to Los Alamos who are now directly contributing to the Laboratory's mission.

(First LDRD experience 2008)



John Lestone, of Radiation Transport Applications (XCP-7), is a leading weapon neutronics expert. Lestone has had a substantial impact on many areas of weapons physics, including his highly impactful weapons research contributions that have advanced new neutron-diagnosed subcritical experiments and allowed the laboratory to exploit data from historic Nevada neutron experiments. Lestone's research that determined the prompt fission neutron spectrum to unprecedented accuracy is an important discovery that has led to widespread use.

(First LDRD experience 2012)



Joseph Martz, of the Materials Science and Technology (MST-DO), is an expert in plutonium chemistry and weapon materials. Martz researched plutonium storage degradation and authored the first Department of Energy plutonium storage standard. Martz proposed the plutonium aging program at the Lab, making critical contributions in understanding pit lifetimes. Martz was the Laboratory's head for the Reliable Replacement Warhead competition and is a popular speaker on nuclear weapon history, testing, design and policy.

(First LDRD experience 2014)



Ralph Menikoff, of Physics and Chemistry of Materials (T-1), is an expert in high explosives (HE) and shock physics. Menikoff's career at the Laboratory has spanned over four decades marked by vital contributions to shock physics and HE science, as well as his leadership in the formulation, implementation and close user support of HE burn models at the core of the Laboratory's mission. Menikoff has been a primary developer of the Scaled Uniform Reactive Front (SURF) model and its successor, SURF-plus, which have become cornerstones of the Lab's approach to HE burn modeling.

(First LDRD experience 2007)

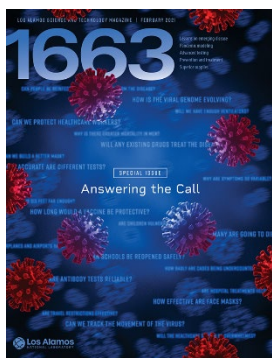
Program Accomplishments

Science in the News

From COVID-19 forecasts to jet fuel produced from corn, LDRD spent the year impacting the nation

5 ways LDRD researchers made an impact in 2020, work conducted and/or in the news in 2020

1: *Front-line fighters in the war against COVID-19*



Beginning in March and still going strong, Laboratory experts in computer modeling and disease forecasting have been some of our most-quoted scientists of 2020. LDRD researchers in the news include computational epidemiologists Sara Del Valle, David Osthus and Carrie Manore; theoretical biologists Bette Korber and Ruian Ke, and manager in Biosecurity and Public Health Jeanne Fair are just a few who shared their knowledge with the nation via Bloomberg News, The Daily Beast, National Public Radio, Public Radio International, The New York Times, Nature and Scientific American, and with New Mexicans in the Albuquerque Journal, KOB-TV, Santa Fe Reporter, Santa Fe New Mexican and many more. For a comprehensive array of research Los Alamos scientists are carrying out to protect us all, read this special issue

of [1663 magazine](#).

2: *X-ray revision*

A [more-sensitive X-ray detector](#) developed at the Laboratory will enable medical and dental imaging at extremely low doses, which is more beneficial for patients. LDRD Physicist Wanyi Nie and her team developed the detector using a thin film of the mineral perovskite, which is 100 times more sensitive than conventional silicon-based devices, reported Physics World magazine in April. Recently, the Physics World editorial team also chose the detector as one of its “[Top 10 Breakthroughs of the Year](#).” Nie’s LDRD work will continue into 2021 (20210533MFR).

3. *Science with heart*

Structural biologist Karissa Sanbonmatsu revealed on KOB-TV4 that unraveling the mysteries of RNA spools could eventually give scientists the ability to [grow new human hearts and better understand heart disease](#). Sanbonmatsu and her team developed the first full 3-D structure of a heart RNA molecule early this year, incorporating research funded by LDRD.



4. *Artificial Intelligence*

[Making sense of vast streams of big data](#) is getting easier, thanks to an artificial-intelligence tool developed at Los Alamos National Laboratory. SmartTensors sifts through millions of millions of bytes of diverse data to find the hidden features that matter, with significant implications everywhere from health care to national security, climate modeling to text mining, and many other fields. This work was featured in the Albuquerque Journal, Newswise, and NNSAnews. The SmartTensors software was developed under a Los Alamos LDRD project titled, “Tensor Networks: Robust Unsupervised Machine Learning for Big-Data Analytics” (20190020DR).

5. Kernels of truth for biofuels

LDRD researchers have been investigating biofuels for over a decade. Biofuels have big potential, as [Popular Mechanics](#) recognized in May when it reported “The new Tomahawk Missile now runs on corn,” detailing how Laboratory scientists developed a replacement jet fuel for the JP-10 made from corn bran and other feedstocks, designed to reduce the U.S. military’s dependency on foreign petroleum.

Research Highlights

The image shows the cover and table of contents of the LDRD Quarterly Highlights newsletter. The cover features the LDRD logo and the title 'Quarterly Highlights'. Below the title, there are three icons representing 'Mission Agility', 'Technical Vitality', and 'Workforce Development'. The table of contents lists various articles and their page numbers, including 'NNSA team uses time-domain spectroscopy to measure transient infrared absorption spectra in gases' on page 1, 'NNSA R&D 100 awards winner and finalist have roots in SDRD' on page 3, and 'Los Alamos researchers re-imagine testing of nuclear material containers' on page 14. The newsletter is dated December 2020.

Stay apprised of the latest technical advances, mission-impact success stories, and notable staff achievements of the NNSA’s premier internal investment resource for high-risk, potentially high-payoff research and development.

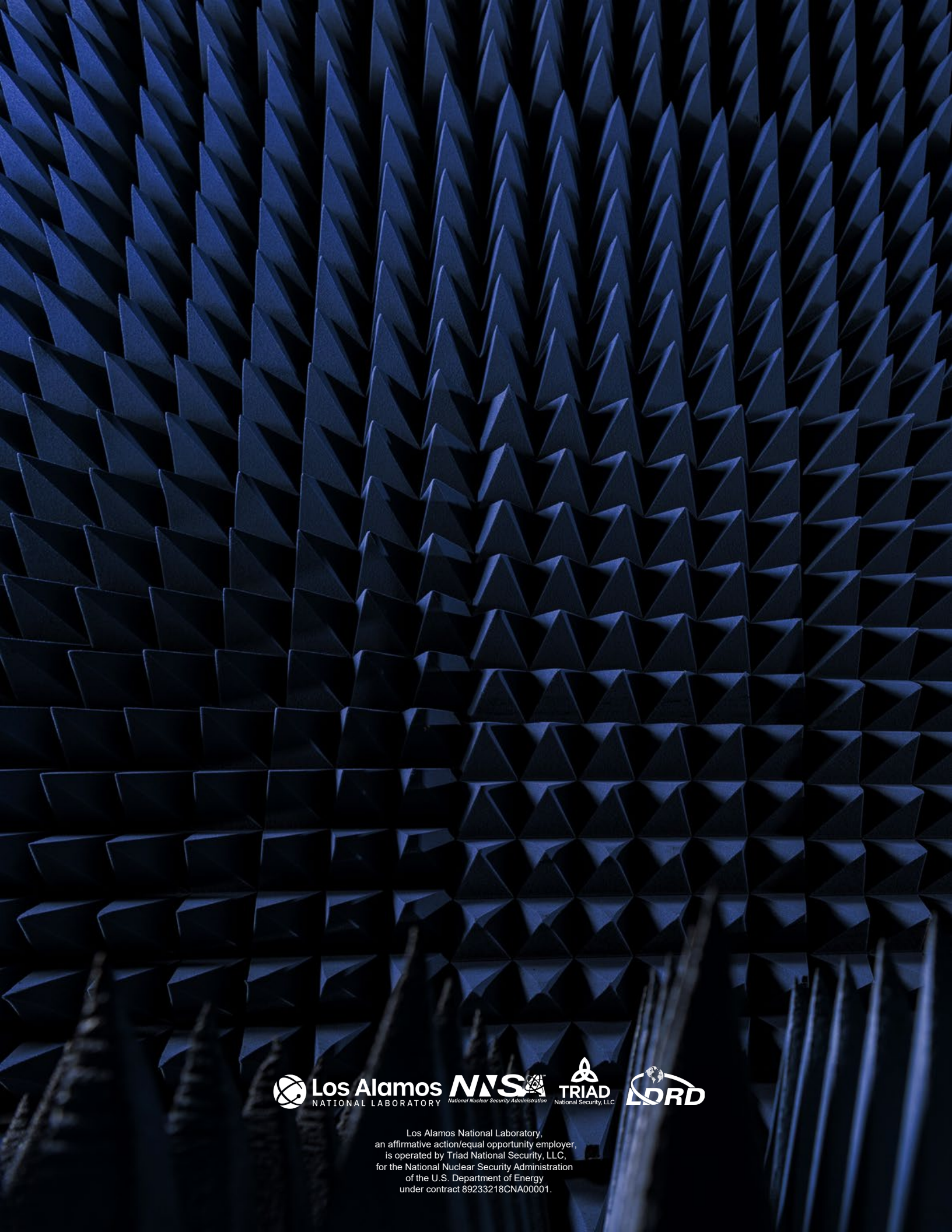
The LDRD Quarterly Highlights newsletter is intended to inform decision makers, foster technology adoption by national security and defense program managers, and enable all readers to:

- Track the development of new and expanding capabilities.
- See how others have implemented recent advances.
- Learn about the programs, products, and collaborations inspired by our leading-edge R&D.

Each story identifies the objectives it best illustrates: mission agility, Technical vitality, workforce development.

FY20 Project Summaries

For FY20 project summaries see the stand-alone compendium available at: <https://www.lanl.gov/projects/ldrd-tri-lab/annual-reports.php>.



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