

Laboratory Directed Research and Development (LDRD) Review by ASCAC* Subcommittee

Martin Berzins

- (i) Overview of LDRD
- (ii) Subcommittee charge and composition
- (iii) Review Process

* On behalf of and with BERAC, BESAC, FESAC, HEPAP, NSAC, DPAC EMB and NEAC

Introduction and Subcommittee Process

Subcommittee Membership

- [Tony Hey \(STFC, UK & UW\)](#) and [Martin Berzins \(Utah\) \(Chair\)](#), Advanced Scientific Computing Advisory Committee (ASCAC)
- [Dawn Bonnell \(U Penn. \)](#) Basic Energy Sciences Advisory Committee (BESAC))
- [Karin Remington \(Computationality LLC\)](#) Biological and Environmental Research Advisory Committee (BERAC)
- [Jolie Cizewski \(Rutgers\)](#) Defense Programs Advisory Committee (DPAC)
- [Beverly Ramsey \(Desert Research Institute\)](#) Environmental Management Board (EMB)
- [Chris Keane \(WSU\)](#) Fusion Energy Sciences Advisory Committee (FESAC)
- [Karsten Heeger \(Yale\)](#) High Energy Physics Advisory Panel (HEPAP) and Nuclear Science Advisory Committee (NSAC)
- [Joy Rempe \(Rempe and Associates\)](#) Nuclear Energy Advisory Committee (NEAC)

Supported by Christine Chalk and Russell Ames and DOE travel staff

What is LDRD

- **Laboratory Directed Research and Development (LDRD)** provides the laboratories with the opportunity to invest in high-risk, potentially high-value research and development that aims to:
 - Maintain the scientific and technical vitality of the laboratories;
 - Enhance the laboratories' ability to address future DOE/NNSA missions;
 - Foster creativity and stimulate exploration of forefront science and technology; and
 - Serve as a proving ground for new concepts in research and development.
- Provides avenue to recruit strategic new hires, support students/post-docs and retain key scientists
- LDRD is the *only discretionary research funding* available to the Laboratory Director to use to strengthen the lab's core competencies and position it for the future. Many LDRD projects address **multiple aims above**

Subcommittee Charge

The June 17, 2015, the interim report of the Secretary of Energy Advisory Board (SEAB) Task Force on DOE National Laboratories recommended an independent peer review of the LDRD program impacts and process of four laboratories, evaluating up to ten years of funded projects.

ASCAC is asked to “review the [LDRD program processes and the impact](#) of LDRD at four of the DOE Labs, to include at least one SC Lab, one NNSA Lab, and one of the applied energy Labs.

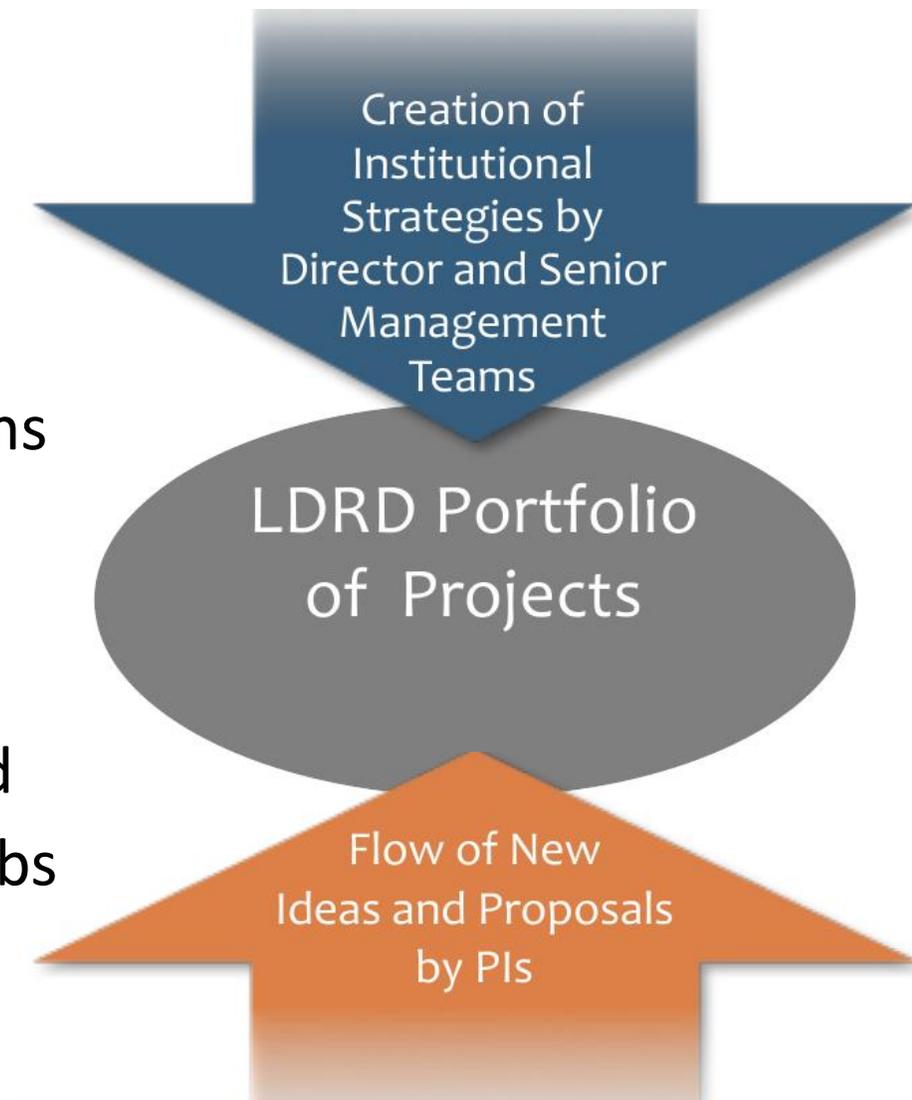
Please choose Labs that have had LDRD programs for at least ten years.

In your review please consider [each Lab's processes to](#):

- (i) determine the funding levels for the LDRD programs;
- (ii) determine Lab-specific goals and allocate resources among the goals;
- (iii) select specific projects; and
- (iv) evaluate the success and impact of the LDRD program against Lab-specific goals and the overall objectives of the LDRD program over a ten-year period.”

Overview of LDRD

- Approximately 1700 projects per year: mixture of strategic and “blue sky” topics.
- Now 4.54% of certified lab cost base in 2016,
- Average spend is \$300k per project with some variations
- About 2000 papers and 400 inventions per year result.
- About 650 (2005) to 1034 (2016) postdocs fully or partially supported
- About 30% of all lab post-docs fully/partially supported
- Higher percentages of postdocs supported at NNSA Labs
- Majority of LDRD projects include early career researchers



Source DOE Reports to Congress 2005 to 2015 and LLNL

Subcommittee Process

Addressed subcommittee charge initially using available information (including lab self-assessments already in place) . Review of previous public reports involving LDRD

Six full subcommittee teleconferences from October through to December .

A number of calls to DOE and to labs were also made to help clarify the charge and the visit agendas

Subcommittee visited the Labs and then used 4 more teleconferences, email and a repository to write the report. The Lab visit reports were fact-checked by the Labs.

This was done on a compressed timescale to meet this meeting deadline.

Subcommittee Process for Lab Visits

Provided guidance document with a detailed set of questions for the four labs based on the committee charge regarding **Processes** to:

- (i) determine the **funding levels** for the LDRD programs;
- (ii) determining **Lab-specific goals** and allocate resources among the goals;
- (iii) **select specific projects**; and
- (iv) **evaluate the success and impact** of the LDRD program against Lab-specific goals and the overall objectives of the LDRD program over a ten-year period with **examples of that impact**.

Consistent questions but without a predefined visit format

Subcommittee Lab Visits

Subcommittee charge request visits to four labs including one SC lab, one NNSA lab and one applied energy lab.

- (i) Lawrence Berkeley National Laboratory Wednesday, January 4th
- (ii) Lawrence Livermore National Laboratory Thursday + Friday January 5/6th *
- (iii) Oak Ridge National Laboratory Thursday, January 26th
- (iv) National Renewable Energy Laboratory, February 2nd

* LLNL visit had a classified briefing that extended our visit

Overview of Lab Visits

Visits varied in format with similar outline:

- Lab Director's overview and LDRD overview
- Lab Associate Directors and leadership team members presented
- Poster sessions with LDRD researchers (and panel session at LBNL) - critical for understanding workforce issues.
- Discussions with LDRD Site Office
- Q/A sessions with lab leadership
- The Labs provided the Subcommittee with the slides of their presentations (some of which are used in the report and here)

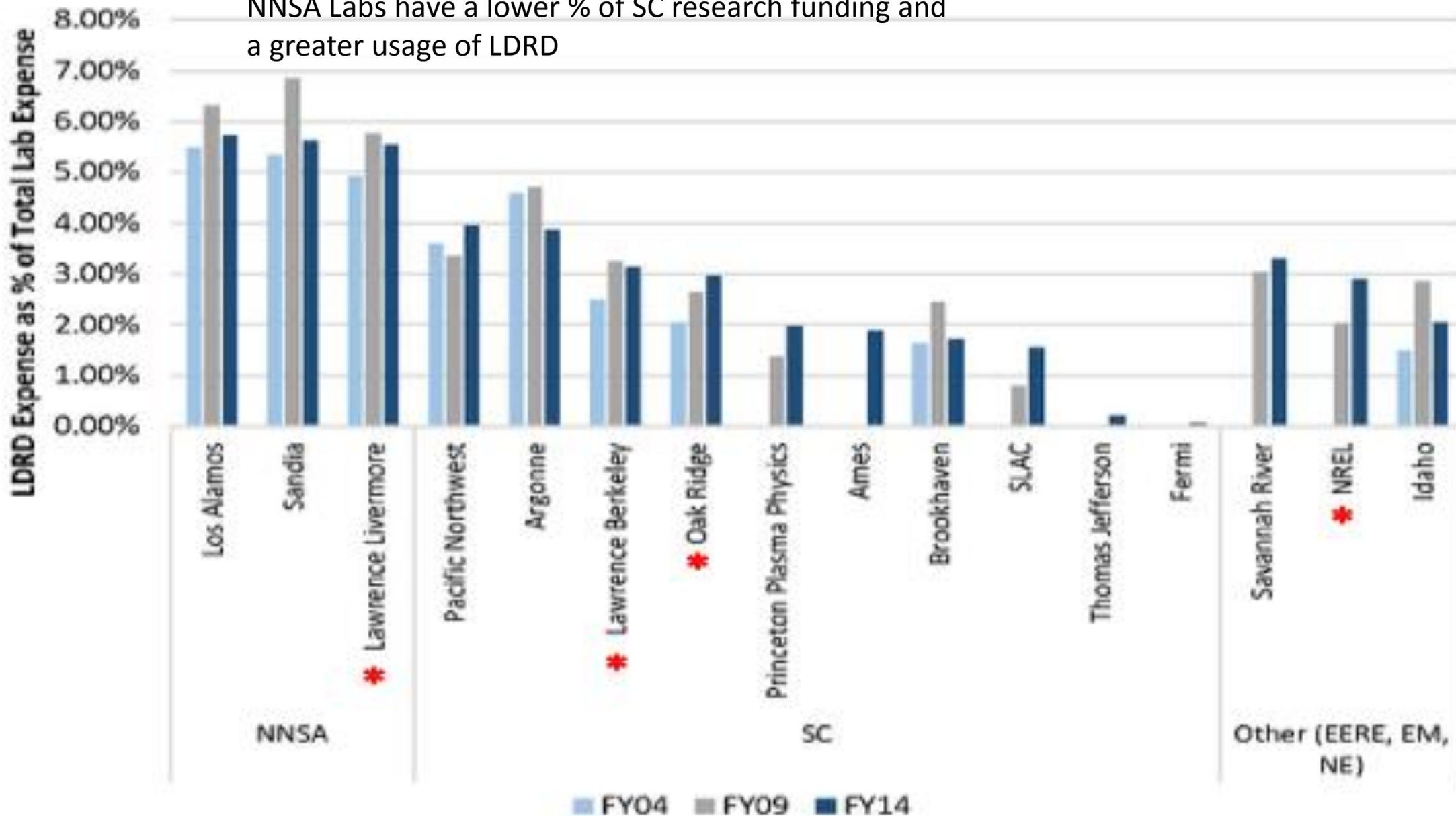
Addressing the Charge

1. Lab's processes to determine LDRD funding levels

(a) Federal Oversight

- Federal oversight spans the entire LDRD lifecycle and drives Lab/DOE Interaction and seems to be at an appropriate level
- Prior to the start of the new fiscal year in September, the Labs and DOE staff meet to discuss the Lab LDRD funding rate levels and program plans
- Each Lab and DOE meet to review and ensure project comply with DOE and other policy (relevance to mission, non-duplication of projects)
- The Field CFO annually reviews LDRD funds accumulation methods and certifies them if they are correct
- DOE HQ also conducts an annual review of each LDRD program for general health, alignment to relevant missions, and effective and efficient execution and evaluation through discussion and site visits

NNSA Labs have a lower % of SC research funding and a greater usage of LDRD



* = Lab visited

1. Lab's processes to determine LDRD funding levels

(b) Internal Lab Processes

In each lab the processes are similar but mission-driven differences

- **In each lab the processes are similar but have mission-driven differences, in all cases driven by strategic issues . Labs balance overhead on other projects with strategic needs**
- Start is annual lab plan development in January, with senior management - the Lab Director and Deputy Lab Director - taking input from the Associate Lab Directors (ALDs).
- The Labs visited each have a deliberate annual review during the budget process to identify the most cost-effective allocation to the LDRD program, up to the Congressionally mandated limit, to maximize the research impact of the funds within DOE.

2. Processes to determine Lab-specific goals and allocate resources among the goals

- Each Lab has a slightly different process for strategic planning and goal setting at the Lab level.
- In general, the Lab Director and Senior Management Team conduct a one- to two- year process:
 - progress review;
 - consideration of new developments in national and DOE priorities;
 - a survey of the needs and opportunities within that context;
 - development of near-term and long-term plans and strategies to best leverage the core capabilities of their Lab to meet those needs and explore promising opportunities.

Example LBNL & DOE Oversight Process

- Program Plan submitted to each Lab's site office to request the program funding rate for the following year
- Site office coordinates with DOE HQ, and funding authorization is given
- Project Datasheets are provided to the site office for each individual project's scope of work, and either concurrence is given or revisions are required
- Any updates to the scope of work or costs are submitted to the local site office for follow-up concurrence
- At the end of the year, the Lab must submit an Annual Report and provide project and program financial data to the DOE CFO's office

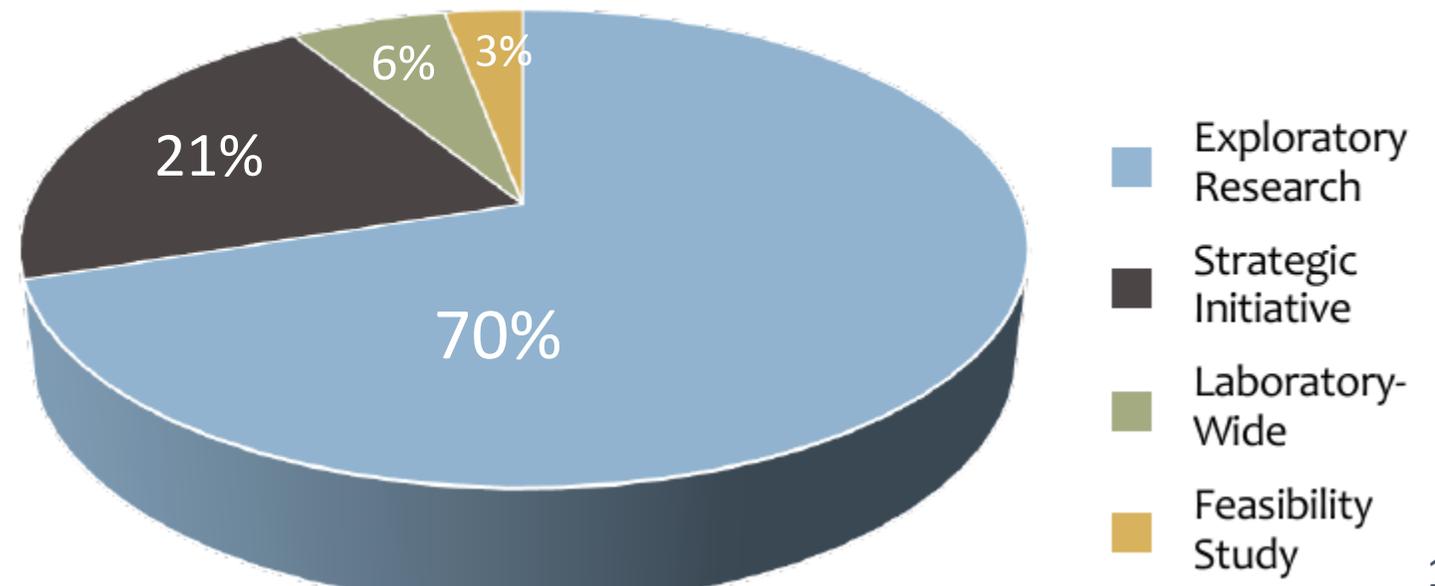
2. Processes to determine Lab-specific goals and allocate resources among the goals

Among the Labs visited, their examples of LDRD components included:

- Strategic Initiatives
- Exploratory Research Projects
- Laboratory-Wide Competitions
- Feasibility Studies (a.k.a. Seed Funding)
- Named Fellowships

Labs visited provided clear descriptions of their process for alignment with goals and allocations of the LDRD funds for each of their LDRD components.

LLNL: FY16 LDRD Funding by Category



Example Approaches to LDRD Funding at LBNL

- Driven by Lab Strategy
 - (Top Down): ~35%
-

- LDRD Call for Proposals sets targeted priorities and aligned with Lab/Area strategy
- ALDs develop additional concepts through town hall meetings and workshops
- ALDs set LDRD priority themes for their areas
- Review of Lab Initiative and Area proposals

- Individual Proposals
 - (Bottoms Up): ~40%
-

- LDRD funding opportunities open to stand alone proposal ideas germinating at the researcher level
- Emerging leaders develop projects as part of their training, independent of any current research initiatives
- Early Career Development Track

- Opportunistic-Reactive: ~25%
-

- Support for anticipated calls for proposals
- Recruiting opportunities
- Retention
- Other

3. Lab Processes to select specific projects

Each Lab has **rigorous, multi-layered procedures to evaluate LDRD proposals** and to assess their progress with collection of metrics of success. Three funding levels:

1. **Highest level of funding (Strategic Initiatives).**

Evaluation processes are the **most rigorous** using **metrics** published in call.

Preproposal or white paper used to select the candidates for full (25 page) proposal.

Review by recognized leaders in ST&E at the laboratory + some **external subject matter experts**.

Detailed technical proposals cut across many disciplines and missions of the Lab.

Proposals cover **alignment with the strategic initiatives** and stress the potential long term and short term **impact** of the project.

Review process always includes **oral presentations (45 minute)** by the PIs.

2 Mid-level funding (i.e. more discipline specific).

- As above **rigorous review** except that outside experts are not engaged.
- Often a **pre-proposal** used to select the candidates for detailed review.
- Review by **recognized leaders** in ST&E at the Lab.
- Full **proposals shorter** than level 1, but still require a strong motivation for the research and the technical methods, as well as the potential short term and long term **impact**
- The review process always includes **oral presentations** by the PIs.
- The proposals are **evaluated using metrics** published in the call for proposals.
- Often proposals not accepted for level 1 funding are considered for mid-level funding, with a restricted scope of the project
- Sometimes includes a general competition, e.g. “**lab-wide competition,**” open to the best ideas, independent of the needs of any specific discipline.

3. Seed funds for feasibility projects.

- Small projects proposed over the course of the fiscal year
- Potential foundation for a future larger scale project.
- **Workshops and mentoring sessions used to encourage good proposals**
- Written proposals and oral presentations are reviewed
- Rigorous review of these “seed” projects is rigorous, with technical panels that often include previous recipients of seed funding.

4. Prestigious postdoctoral fellowships.

- LDRD funds used to attract the “best and the brightest” postdoctoral scholars o
- Candidates submit a comprehensive package of CV with a 2-3-year proposal
- Fellowship application and research proposal are reviewed by ST&E leaders and senior managers of the Lab
- Process includes oral presentations.

LDRD Process by Calendar Month at LBNL

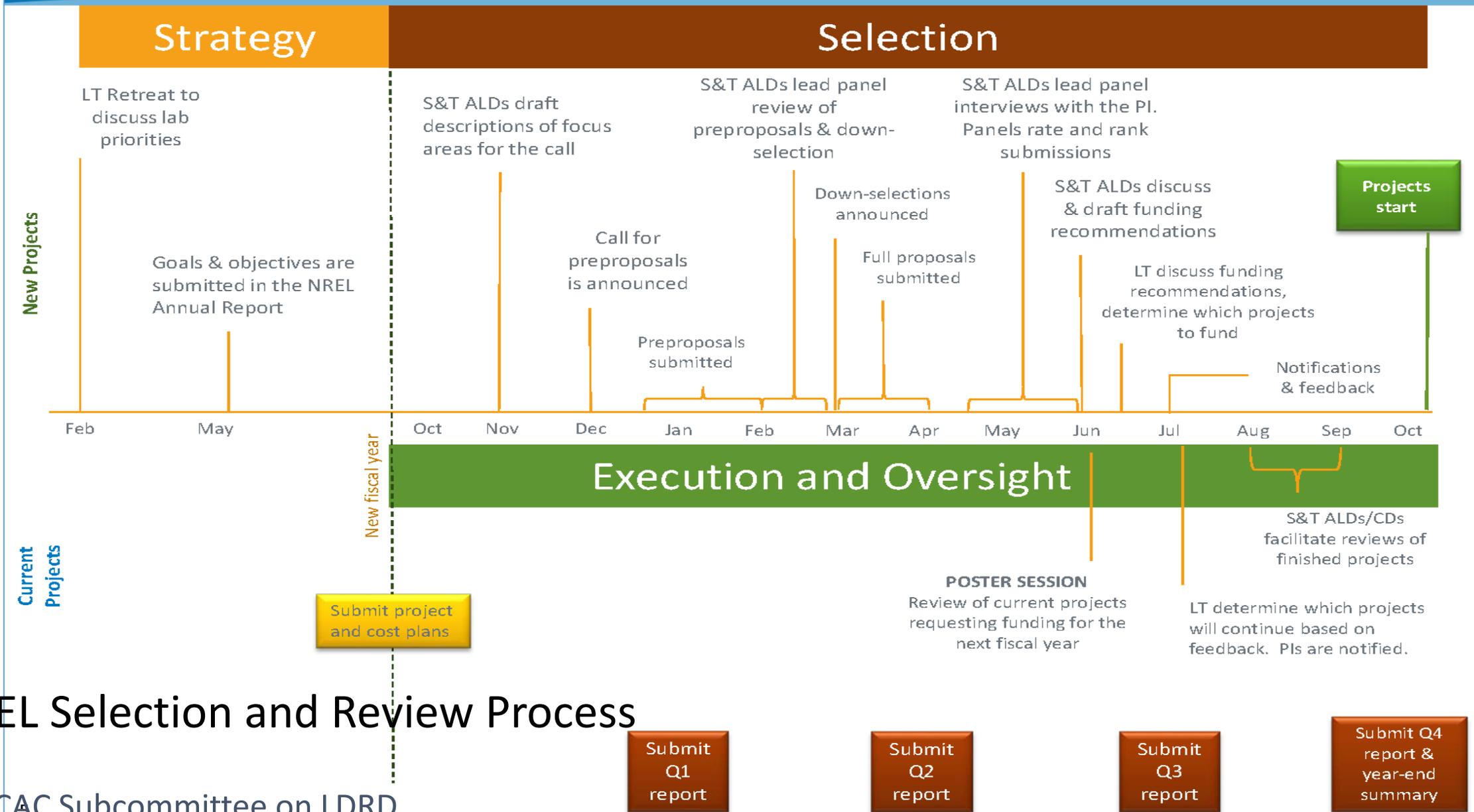
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<p>Lab Director develops annual lab plan with ALD and DD input</p> <p>YEAR 1</p> 		<p>ALP is presented to DOE</p> 				<p>ALDs develop input for LDRD call with ALP information</p> 				<p>LDRD Call for Proposals is</p> 	

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<p>Labwide discussions of strategy, proposal idea development</p> <p>YEAR 2</p> 	<p>Proposals submitted</p> 	<p>Proposal review</p> 	<p>Funding decisions, DOE approvals</p> 				<p>Projects start</p> 				

Out of cycle project starts are possible (subject to available funding)

Source LBNL

LDRD Process Flow Chart



NREL Selection and Review Process

Processes to evaluate the success and impact of the LDRD program against Lab-specific goals and the overall objectives of the LDRD program over a ten-year period.

1. Evaluation during after project funding.

- Quarterly Reviews to monitor spending schedule
- Mid-year reviews to assess the progress towards meeting the proposed milestones and be on track for impact post-award.
- For problem projects, Lab staff work with the PI to help meet technical and financial milestones.
- If milestones are not being met, a project can be terminated.
- Multi-year projects are reviewed by subject matter committees before funding for a second (or third) year is awarded.

2. Reporting outcomes.

- All LDRD projects at all Labs are required to annually report the progress and products of their efforts.
- The progress is summarized in the Lab's annual LDRD report that includes metrics such as publications in peer-reviewed professional journals, invited presentations at national and international venues, and intellectual property.

2016

Total Post-Docs = 3310 LDRD Supported = 1034 is 31.2%

Publications 2013 2014 2105

2109 2056 2422

Patents 188 Inventions disclosures 328

3. Long Term Impact Evaluation.

- LDRD long-term impact is evaluated as part of Lab strategic activities
- The meetings and/or whitepapers held/submitted at the beginning of the LDRD cycle typically consider past successes on their way to defining current areas of strategic importance.
- Long term view taken (often as far out as a decade), to invest in areas where expertise is likely to be required in the future.
- Feedback from current work influences future activities. E.G. LLNL has a formal exit plan for each proposal that identifies the future path forward.
- ORNL monitors project outcomes for three years post. Other labs also monitor outcomes but sometimes more for the strategic initiatives.
- Fine scale impact of LDRD projects is also reviewed through the performance reviews of the individuals who undertake the work and its potential follow-on projects.

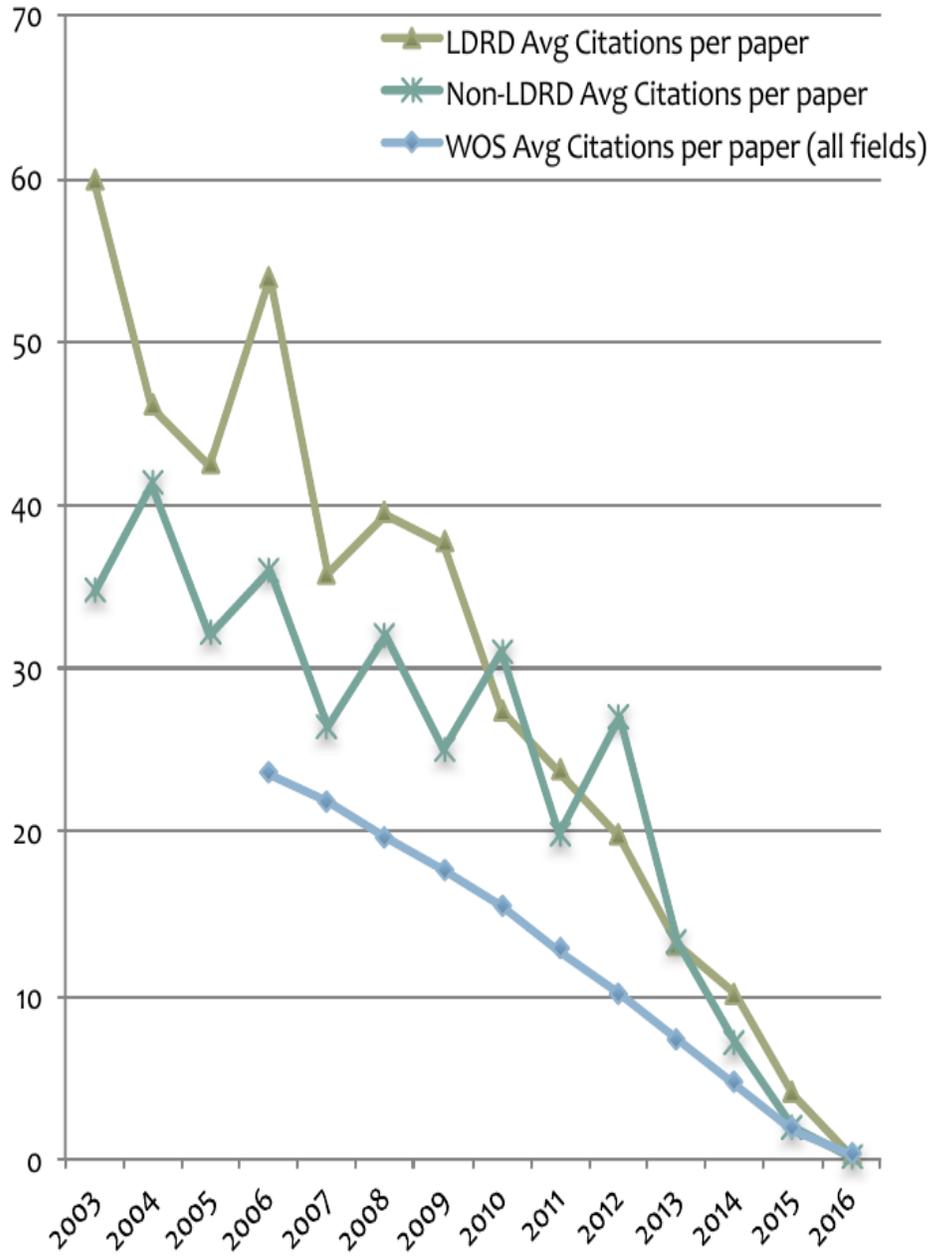
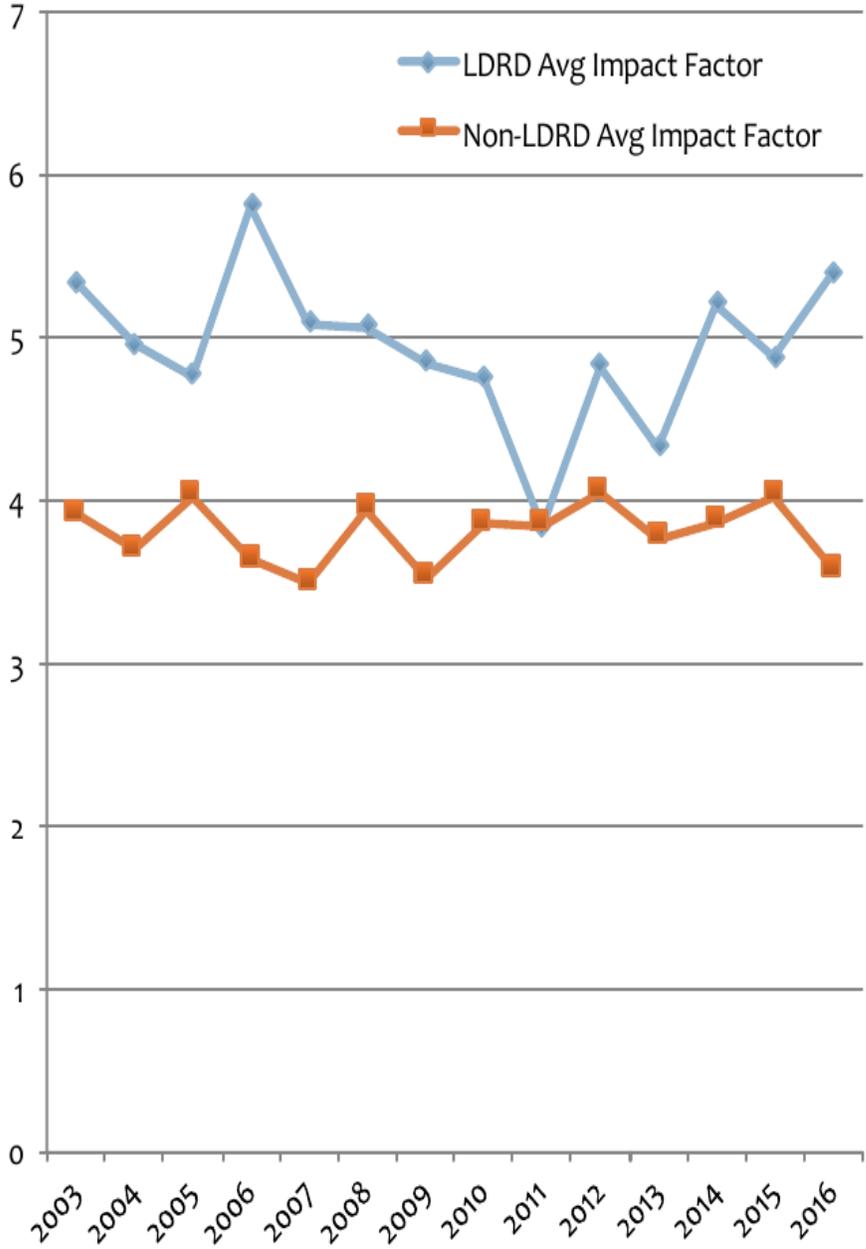
Impact of LDRD

Best assessed with respect to the LDRD goals

- Maintain the scientific and technical vitality of the laboratories;
- Enhance the laboratories' ability to address future DOE/NNSA missions;
- Foster creativity and stimulate exploration of forefront science and technology; and
- Serve as a proving ground for new concepts in research and development.

1. Maintain the scientific and technical vitality of the laboratories;

1. Key impact of LDRD that enables vitality is the ability to recruit new staff and nurture existing staff.
2. LDRD is used to attract post-doctoral researchers and occasionally more senior scientists with critical new skills to work on unclassified projects that are key for meeting Lab strategic goals.
3. LDRD is essential at National Nuclear Security Administration (NNSA) Labs because of the time required for new staff to obtain security clearances.
4. It is not only the influx of new technical staff that is enabled by LDRD but also the type of innovative research supported by LDRD that is critical to maintaining laboratory vitality and is reflected by the quality of outputs .
5. E.G. Of the ORNL 429 PIs and co-PIs on NNSA FY17 LDRD projects, 46% are early career staff.



LDRD Publications have more impact and are better cited
Source LLNL

1. Maintain the scientific and technical vitality of the laboratories;

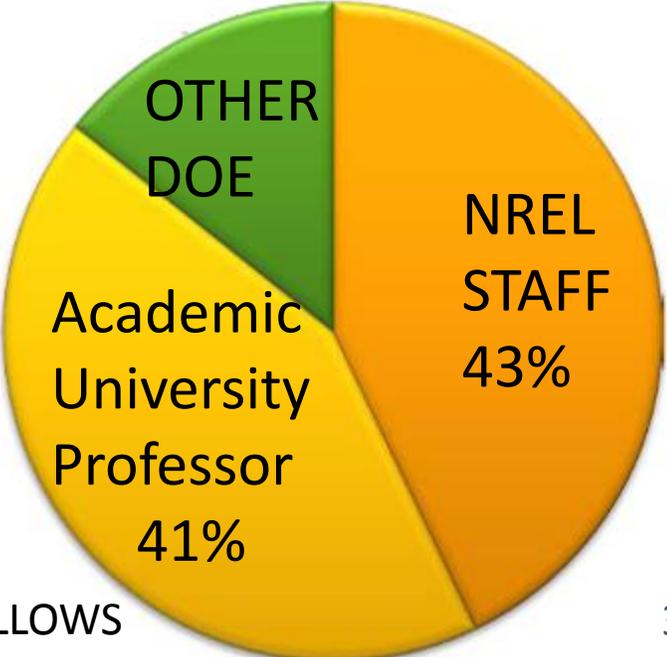
LDRD has supported over 55% to 90% of the post-doctoral researchers at LLNL over the past 10 years, and typically, 20% to 40% of post-doctoral researchers convert to LLNL staff positions.

At ORNL, – the Wigner, Weinberg, Householder and Russell Fellowships - are used to attract talented early career staff Since 2007, 56% of Wigner Fellows have been retained at ORNL LDRD has also been used at ORNL to make strategic staff hires and since 2005 - 26 hires with 96% retention

At NREL there is a very high conversion rate to NREL staff

All this helps to build a healthy influx of new people and ideas

Career Path after Fellowship



2. Enhance the laboratories' ability to address future DOE/NNSA missions

- LDRD allows the Labs to undertake research that enhances their core capabilities
- LDRD has produced paradigm changes in critical areas.
- LDRD provides flexibility across a single framework for the future needs of DOE interests across a diverse set of Labs in a way that would be almost impossible in a conventional program
- LDRD is required to conduct fundamental research for developing novel new ideas and techniques that experience has shown will be key to addressing future program needs.

2. Enhance the laboratories' ability to address future DOE/NNSA missions

- Subcommittee saw a broad portfolio of work that showed that that many LDRD projects initiated to enhance core capabilities have revolutionized the way Labs meet current and anticipated future needs.
- LLNL's advanced manufacturing LDRDs have led to better materials being produced more rapidly and at lower cost for several Lab customers. Their work on space technology and Plutonium aging has had broad impact.
- NRELs work on Perovskite* has improved the efficiency of solar cells threefold.
- ORNLs work on extreme scale computing and radiation has well defined future capabilities and significant follow-on .
- LBNL's work on Applied Math Camera and Microbes to Biomes and the Joint Bioenergy Institute (\$250M DOE funding) all came from LDRD.

Securing ORNL leadership in radiation transport

Terascale
Simulation Tools
for Next-Generation
Nuclear Energy
Systems
(2 years, \$876k)

Denovo:
Next-Generation,
High-Performance
Computing Solver
for Multiscale
Nuclear Energy
Transport
(2 years, \$628k)

2006

2009

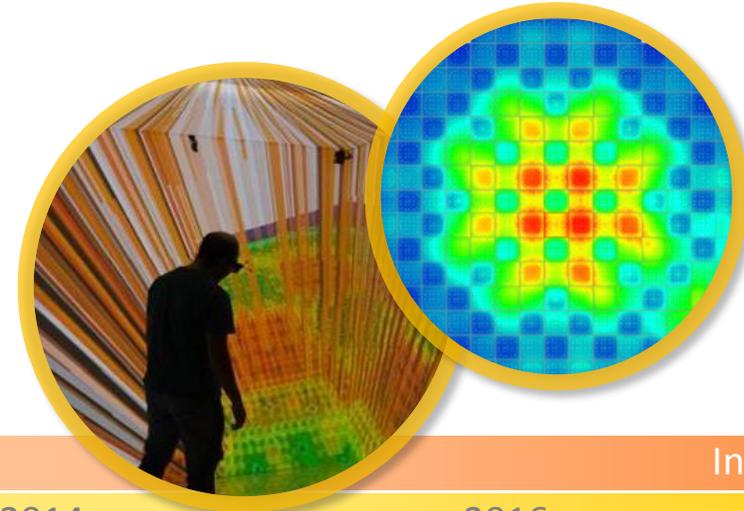
2010

2014

2016

Investments

Impacts



VERA
simulation
of Watts Bar
Unit 2 startup



Winning proposal
for ORNL-led
NE Hub: CASL
(10 years, \$250M)
Wagner and Evans
lead Radiation
Transport Methods
Focus Area

International
Data Corporation
HPD Innovation
Award based on
Denovo/Exnihilo
simulations
of AP1000

ECP application
development
project: \$10M
R&D 100 award
for Virtual
Environment
for Reactor
Applications
(VERA)



3. Foster creativity and stimulate exploration of forefront science and technology

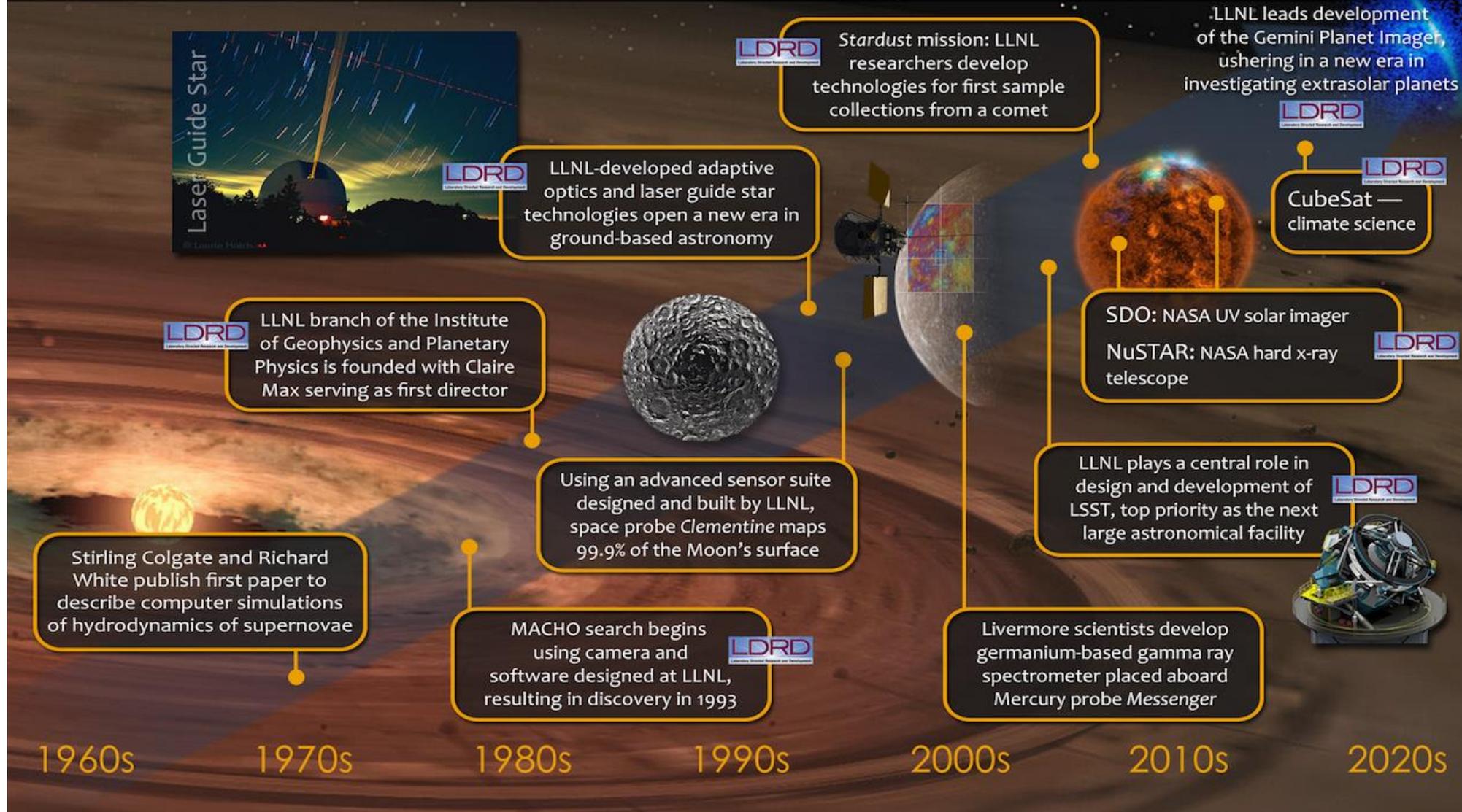
Labs leverage LDRD by encouraging strategic collaborations with universities, industry, and other national Labs. For example

- The LLNL **SPACE Program** is a proving ground for new R&D concepts within this mission area that have direct overlap and “dual-use” applicability to core Lab programs (e.g., Stockpile Stewardship).
- ORNLs work enabling **large scale Additive Manufacturing** for industry, where 2 LDRD projects led to \$50M in DOE funding, 50 publications, 25 disclosures and 7 patents and helped create U.S. jobs and kept the U.S. competitive
- NREL’s **Grid Modernization / Energy System Integration project** that provided the framework for the Department of Energy’s Grid Modernization Laboratory Consortium.
- LBNL Doudna’s CRISPR DNA strands – “Biggest Biotech Discovery of the Century” –MIT Tech. Rev

LLNL has been doing forefront research in space science since the earliest days of the Lab

LDRD in Action

8 LDRD projects Contributed over 50 years



ORNL Enabling industry growth in large-scale AM

2 LDRD projects

- FY14: “Large Scale, Out of Oven AM” (PI: Love)
- FY15: “Big Area AM” (PI: Love)

DOE AMO project: >\$50M, FY14–FY16

- AMO: \$46M, including \$3.5M BAAM system
- SPP, DOE Wind, industry cost share: \$5.2M

Staff hired

- 2 FTEs: Brian Post, Andrzej Nycz
- 5 postdoctoral fellows

Intellectual property

- 19 journal articles; 30 conference papers
- 25 invention disclosures; 7 patents; 9 licenses
- 6 awards (including 2 R&D 100 Awards)

Technical impacts:

Unprecedented deposition rates in world’s largest AM printers with >26 materials evaluated in <1 year

Composites tooling, world’s largest 3D printed object (777X wing tip trim tool), bio-derived material printing, high-performance magnets

DOE mission impact:

Development of commercial mainstream printers that can efficiently fabricate objects such as wind turbine blade molds, aircraft composite tooling, and 3D printed cars

Industry impact:

12 BAAM systems sold (>\$1M per system); >40 companies making new business opportunities



Wind turbine blade mold

4. Serve as a proving ground for new concepts in research and development.

- NREL work on solar cells above
- NREL 12/20 posters had DOE follow on of \$20M
- ORNL Radiation work, Additive Manufacturing
- LLNL High performance computing for exascale
- LBNL's Camera activities where three LDRD grants introduced an activity that applied novel math to several new Lab areas and awarded a \$10M DOE grant to continue this work
- Proof of concepts evaluations helped with ORNL Advanced Neutron Source, LLNL National Ignition Facility , LBNL Advanced Light Source

5. Support High Risk High Value R&D

- Rapid funding and adaptive nature makes possible rational risk taking in a way that is difficult in established programs.
- Leads to novel high-impact publications (see above).
- LBNL Perlmutter – computational innovations to measure the parameters of the Universe. Noble prize 2011.
- LDRD's agile nature and relatively low funding also help show that promising ideas may not be so, thus saving money
- Allows Labs to take a long-term view that pays off in many cases.

Summary of Charge Responses

What are the processes to determine the funding levels for the LDRD programs?

These processes **balances the strategic needs** of the Lab **against the overhead burden** on other Lab funding.

Differences reflect varying Lab missions and the need to **balance strategic research** against blue-sky high-risk research and fellowships to ensure recruitment.

Great care is taken to address Lab strategic/operational needs within Congressional bounds.

What are the processes to determine Lab-specific goals and allocate resources among the goals?

Each Lab has a slightly different process for goal setting.

An informed **high-level strategic view** taken by senior management **defines the goals and areas** for projects to address and aligns the majority of LDRD activities with Lab goals

Leaves room for **ground-up blue-sky funding** and Lab fellowships to introduce novel approaches that will contribute to and help shape evolving Lab priorities.

What are the processes to select specific projects?

Multi-level procedures with the expended effort being proportional to the likelihood of funding and with feedback levels are used in a constructive approach to project selection.

White papers leading to full papers and presentations are typically used in conjunction with mentoring to reduce wasted effort.

The processes appear to be **fair and well-managed with a strong developmental aspect** that is both noteworthy and efficient in the long term.

What are the processes to evaluate the success and impact of the LDRD program against Lab-specific goals and the overall objectives of the LDRD program over a ten-year period?

The procedures for evaluating success and impact include a **high-level federal aspect** and a **detailed laboratory aspect** with **multiple levels of evaluation** at different times.

This includes external expert review and, for some of the Labs, **exit plans and post-project assessment** over several years (typically two to five), following the end of the project.

What is the impact of the LDRD program?

The Subcommittee observed the considerable and long-lasting impact of LDRD projects at a number of different levels. These range from

Research metrics such as publications and patents, through to spin-off companies and follow-on DOE programs that build upon the research led by LDRD.

The use of LDRD to provide fellowships for new hires and blue-sky research had a profound impact on the quality of both the research undertaken and the caliber of the Lab staff undertaking it.

How LDRD program has allowed Labs to better accomplish their mission as well as allowing them to respond rapidly to emerging issues and to allow the US to remain at the forefront of technology.

Observations Recommendations and Best Practices

LDRD must be maintained at its present level to attract and retain the high-quality workforce DOE Labs currently enjoy.

LDRD provides a way to offer new and existing staff the opportunity to explore new challenges, while improving the research strengths of the Labs, meet current mission goals, and be prepared for future national challenges.

LDRD is essential to maintaining the Labs Science Technology and Engineering (ST&E) base both now and in the future.

Longer-term LDRD fundamental research aimed at developing the new ideas and techniques that will be key to addressing future energy and national security challenges.

The Labs should introduce processes, (some do already), to document and highlight the longer-term (> 5 year) impact of LDRD as a national asset. E.G. consistent process to track and understand the impact of projects and publications so that it is clear which LDRD projects led subsequent beneficial activities.

Observations Recommendations and Best Practices

- There should be **informal LDRD co-ordination** between non-NNSA Labs as presently exists between the NNSA labs as this will likely help increase the impact of LDRD across the Lab system and beyond.
- Some **LDRD best practices** at the Labs might be **deployed more broadly**
- **“Lead reviewers” for all proposals**, with duties beyond simply reviewing the proposal
- **“LDRD Points of Contact”** within the major laboratory directorates to play a critical role in ensuring program integration in all areas of the LDRD program;
- every project should have an **exit strategy to help maximize impact**;
- a clear statement of **how every proposal benefits DOE** in the annual reports.

Conclusions

- LDRD Program provides a **unique combination of high-level laboratory-driven strategic research and “blue sky”, investigator driven, fundamental research** based upon individual innovation in a framework that has constructive federal, laboratory and external oversight at multiple levels.
- the LDRD program appears to be **very well run and monitored**, in accordance with the intent of the DOE program, and with processes that couple innovation at the Laboratory and individual scientist level with the Nation’s anticipated future security, energy, science and engineering needs.
- Both the level of funding and the **LDRD funding processes are appropriate and necessary for the Labs** to continue to perform at their present high levels of R&D for the DOE.
- A more **systematic approach to** monitoring the **long-term impact** of the LDRD program at the Labs would make it easier for the great successes of the program to be more widely understood and appreciated.