Laboratory Directed Research and Development (LDRD) Review

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ASCAC Subcommittee on LDRD

on behalf of and with RAC, BESAC, FESAC, HEPAP, NSAC, DPAC
EMB and NEAC

based on presentation by committee chair Martin Berzins

Subcommittee Membership

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Basic Energy Sciences Advisory Committee (BESAC)

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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

On 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.”

charge letter - https://science.energy.gov/ascr/ascac/reports/

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

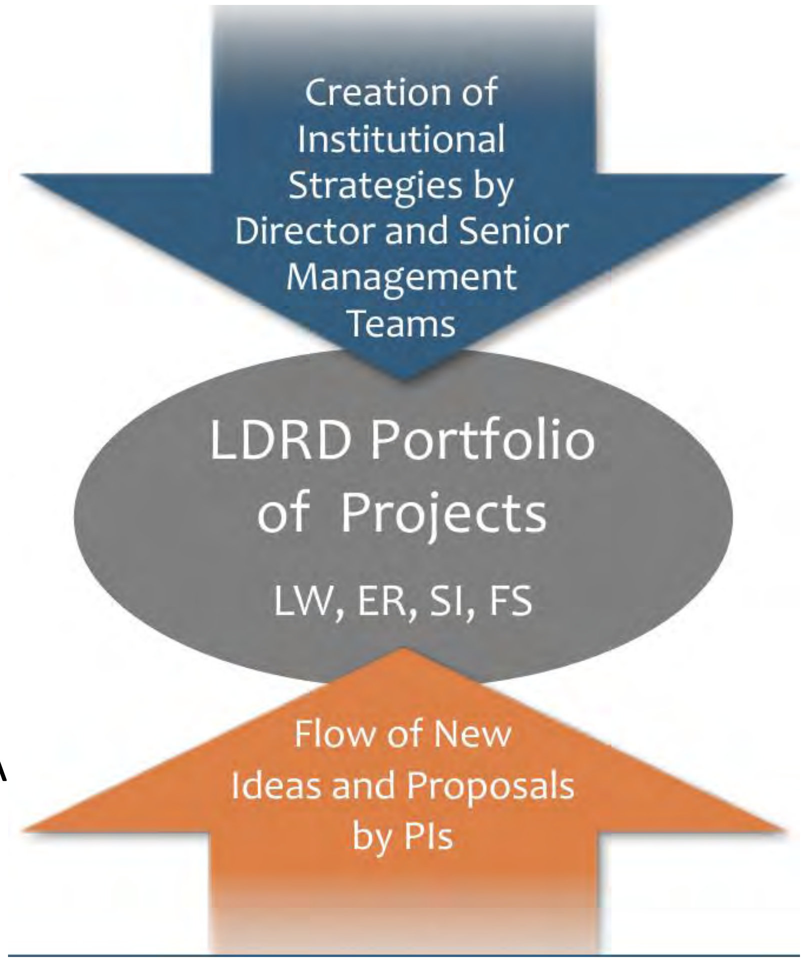
• About 2000 papers and 400 inventions per year result

• 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

Received information about the lab's LDRD process ahead of visits.

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.

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 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

Lab's Process to Determine LDRD Funding Level

(a) Federal Oversight

• Federal oversight spans the entire LDRD lifecycle and drives Lab/DOE Interaction and seems to be at an appropriate level

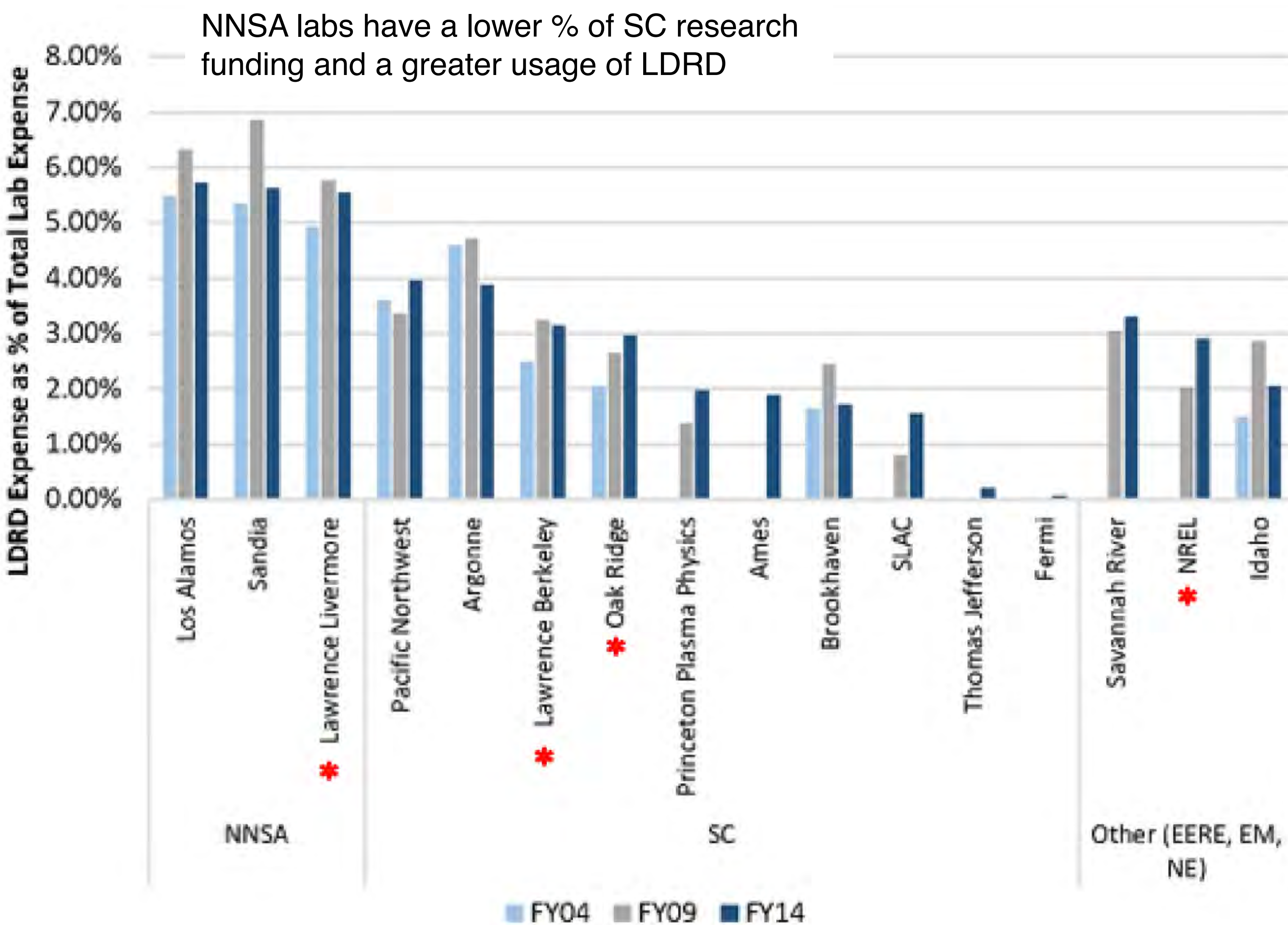
• Prior to the start of the new fiscal year in September, the Labs and DOE staff meet to discuss the Lab LDRD funding rate levels and program plans

• Each Lab and DOE meet to review and ensure projects 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

LDRD Expenses



*=labs visited

Lab's Process to Determine LDRD Funding Level

(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.

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

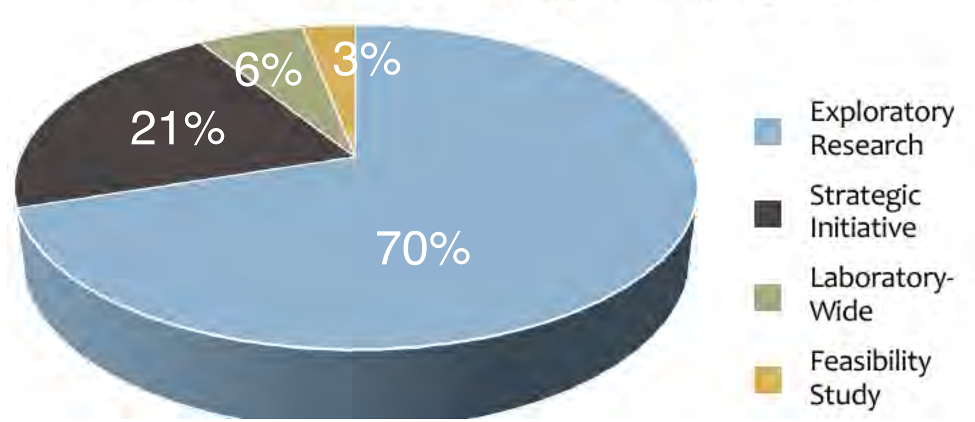
Each Lab has a slightly different process for strategic planning and goal setting. In general, the Lab Director and Senior Management Team conduct a one-to two-year process:

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



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

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%

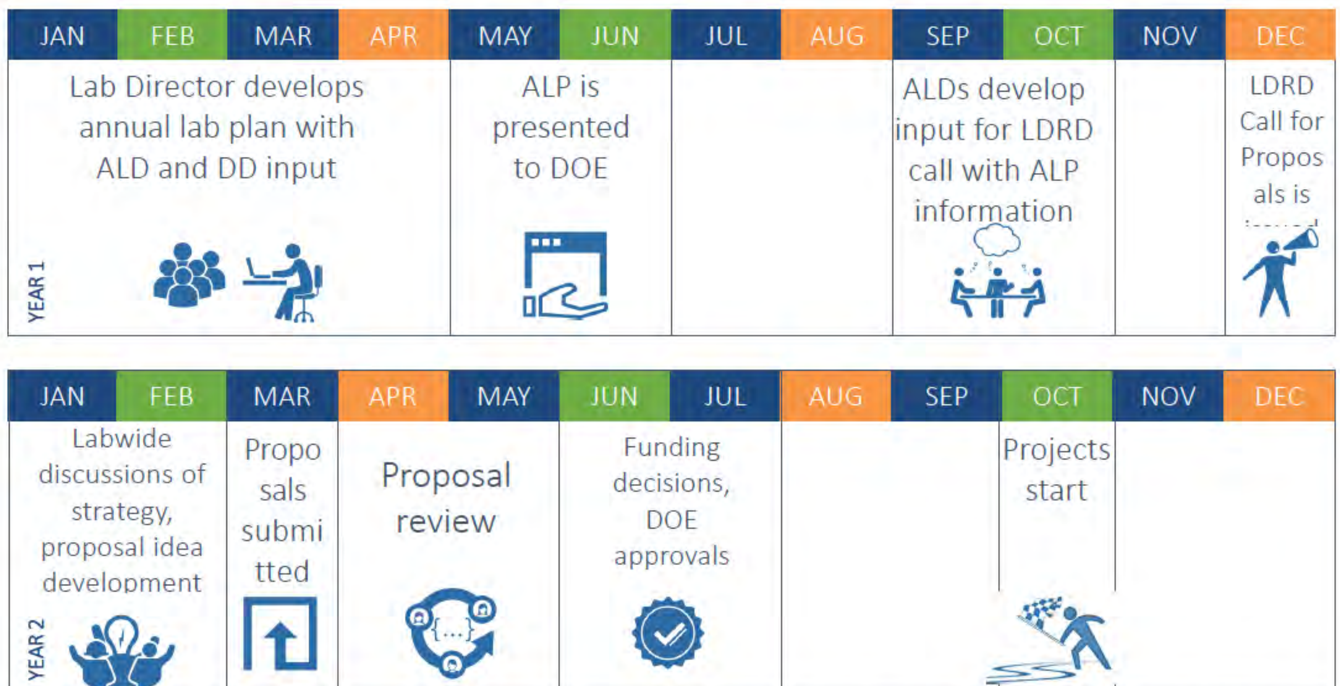
- Support for anticipated calls for proposals
- Recruiting opportunities
- Retention
- Other

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:

- Highest level of funding (Strategic Initiatives).
- Mid-level funding (i.e. more discipline specific
- Seed funds for feasibility projects
- Prestigious postdoctoral fellowships.

Example:
LDRD Process
at LBNL

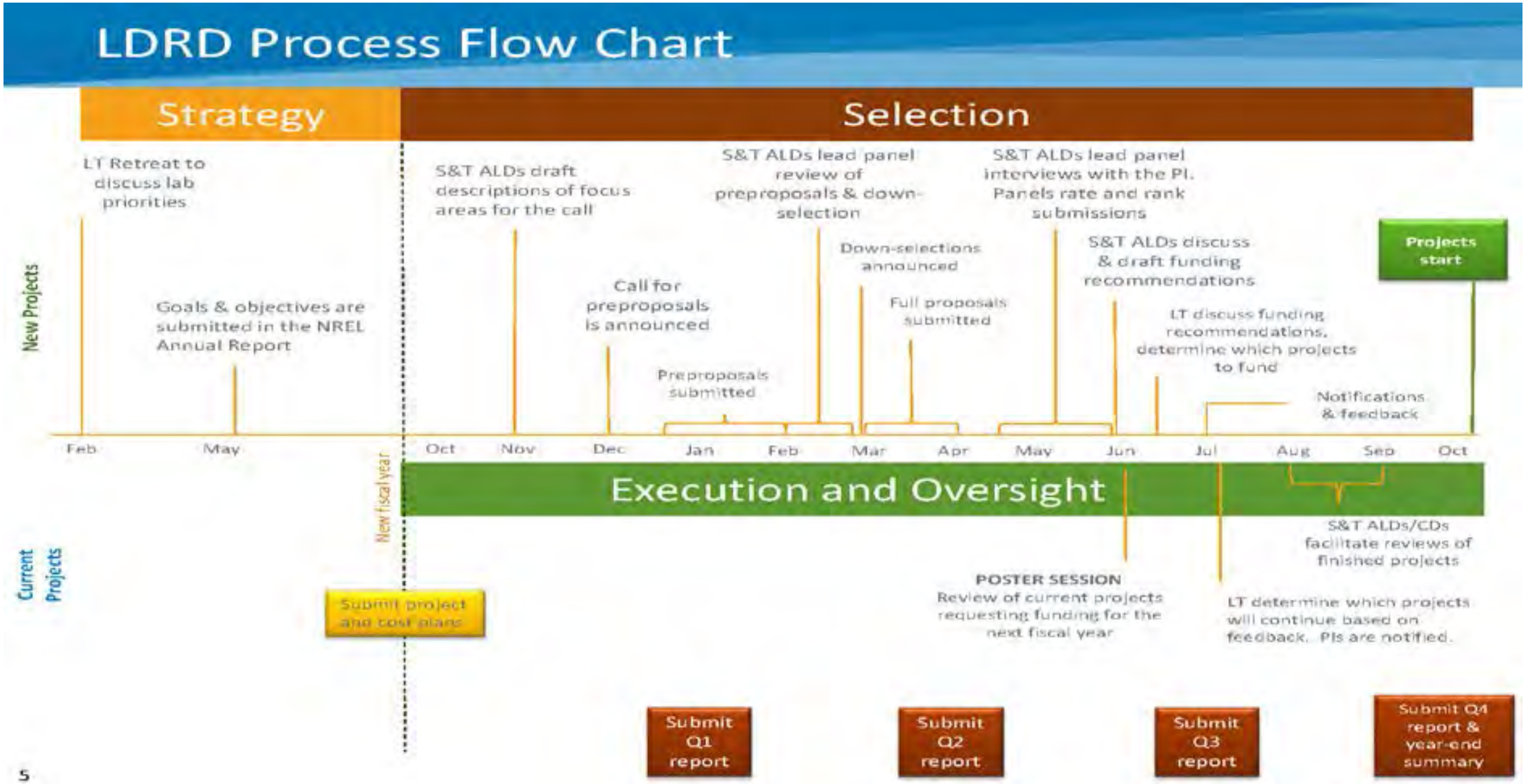


Out of cycle project starts are possible (subject to available funding)

Source LBNL

Lab Processes to select specific projects

NREL LDRD Selection Strategy and Oversight Summary



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

• Reviews to monitor spending schedule and to assess the progress towards meeting the proposed milestones. If milestones are not being met, a project can be terminated.
• Multi-year projects are reviewed by subject matter committees before funding for following year

2. Reporting outcomes

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

3. Long Term Impact Evaluation

• LDRD long-term impact is evaluated as part of Lab strategic activities
• The meetings and/or whitepapers at the beginning of the LDRD cycle typically consider past successes to define current areas of strategic importance.
• Long term view taken 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

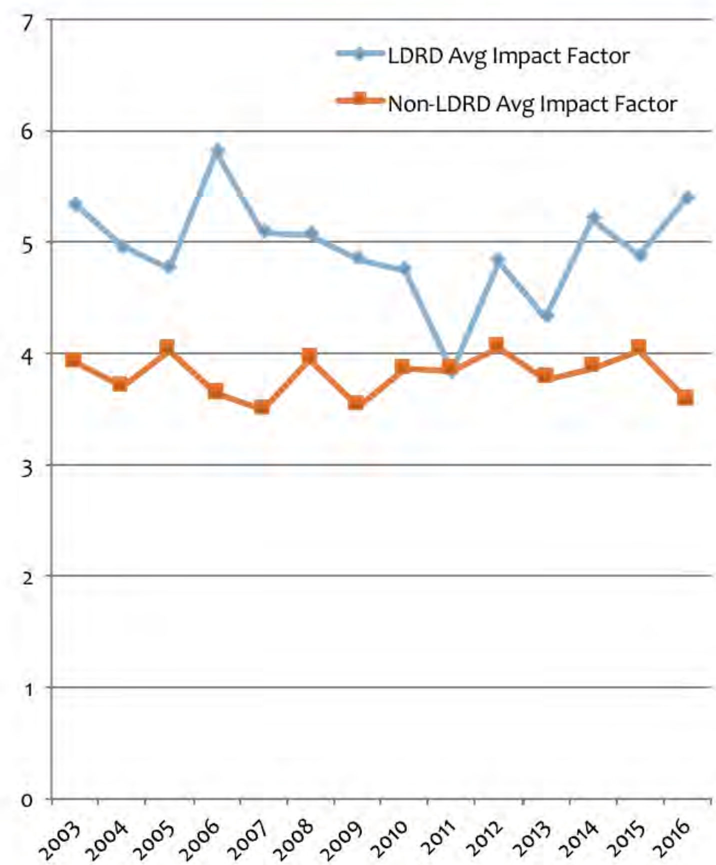
1. Maintain the scientific and technical vitality of the laboratories

Key impact of LDRD that enable vitality is the ability to recruit new staff and nurture existing staff.

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.

It is not only the in flux 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.

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)

Impact of LDRD

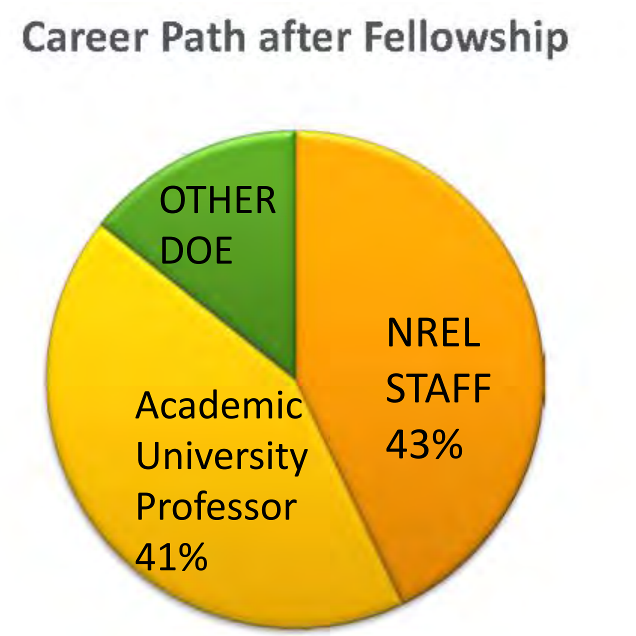
1. Maintain the scientific and technical vitality of the laboratories

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. 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.



NREL FELLOWS

Impact of LDRD

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 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

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.

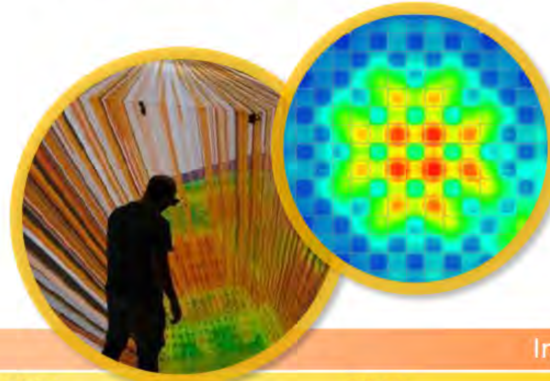
Impact of LDRD

Securing ORNL leadership in radiation transport

Investments

2006 — Terascale Simulation Tools for Next-Generation Nuclear Energy Systems (2 years, $876k)

2009 — Denovo: Next-Generation, High-Performance Computing Solver for Multiscale Nuclear Energy Transport (2 years, $628k)



VERA simulation of Watts Bar Unit 2 startup

Impacts

CASL
Consortium for Advanced Simulation of LWRs

2010 — Winning proposal for ORNL-led NE Hub: CASL (10 years, $250M)

Wagner and Evans lead Radiation Transport Methods Focus Area

2014 — International Data Corporation HPD Innovation Award based on Denovo/Exnihilo simulations of AP1000

2016 — ECP application development project: $10M

R&D 100 award for Virtual Environment for Reactor Applications (VERA)

R&D 100

Impact of LDRD

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.

- e.g. 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).

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

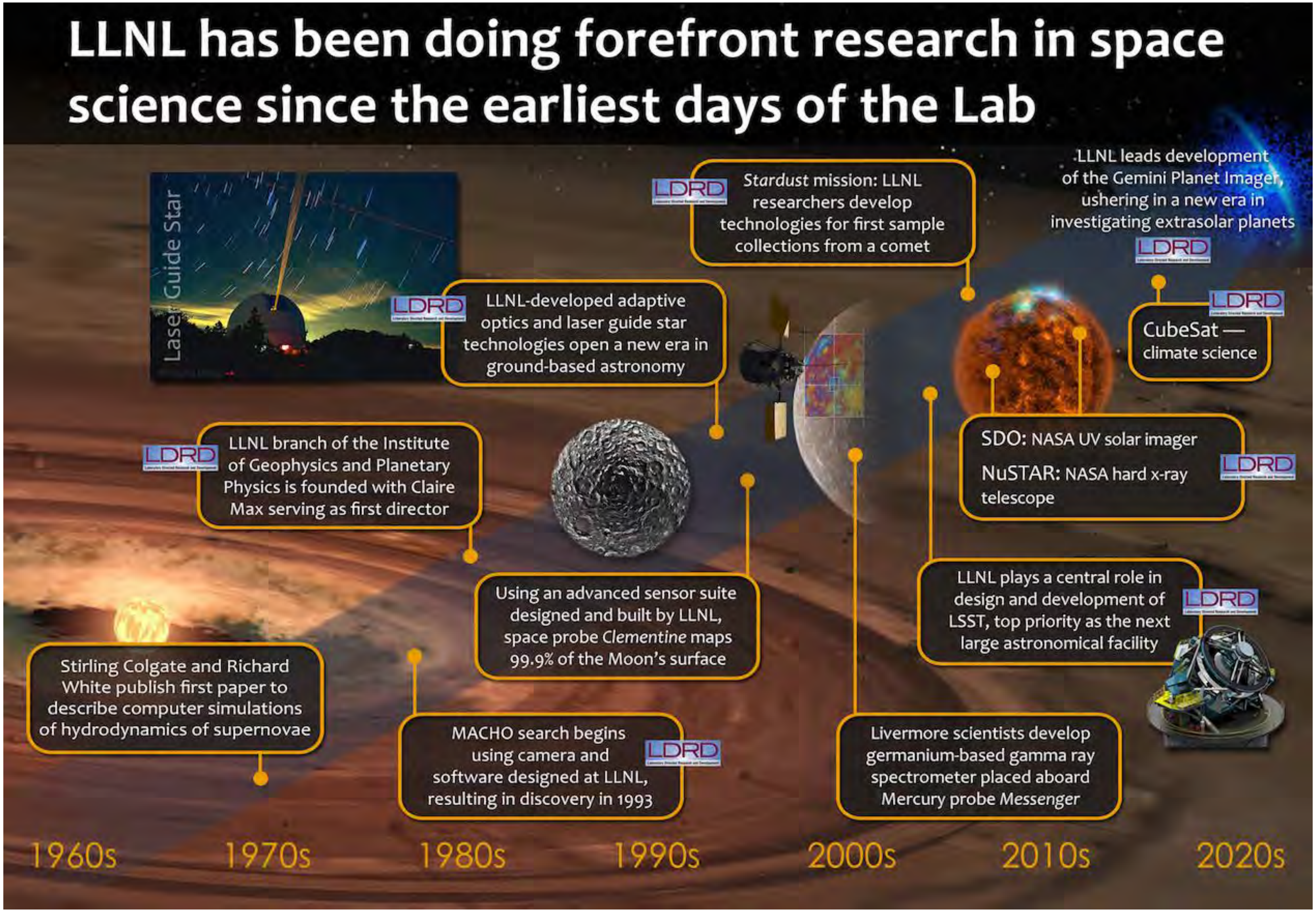
- NREL work on solar cells above
- ORNL Radiation work, Additive Manufacturing
- LLNL High performance computing for exascale
- Proof of concepts evaluations helped with ORNL Advanced Neutron Source, LLNL National Ignition Facility , LBNL Advanced Light Source

5. Support High Risk 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–innovations to measure the parameters of the Universe. Noble prize 2011.

Impact of LDRD



8 LDRD projects contributed over 50 years

Impact of LDRD

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)

Wind turbine blade mold

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

Observations, Recommendations, Best Practices

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

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.

There should be informal LDRD co-ordination between non-NNSA Labs as presently exists between the NNSA labs.

Some LDRD best practices at the Labs might be deployed more broadly:

- "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.

• 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.

report - https://science.energy.gov/ascr/ascac/reports/