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Improving Army Basic Research

Report of an Expert Panel on the Future of Army Laboratories

PANEL ON THE FUTURE OF ARMY LABORATORIES

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Summary

Background and Purpose

This report describes the result of an expert panel, referred to in this report as the Panel on the Future of Army Laboratories,[1] assembled to consider how current trends in research and development (R&D) might unfold over time, and how those trends could affect the laboratories and R&D centers that support the Army. The panel was convened based on the idea that the U.S. Army will be in the midst of an unprecedented technical transformation for the foreseeable future as it rapidly adopts and adapts to cutting-edge science and technology to remain an effective and relevant fighting force. In this era of accelerating innovation, it is likely that many of the new concepts needed to make the Army's transformation a reality will be realized only through the discovery and application of breakthrough R&D. Therein lies a potential challenge for the Army's R&D planners.

To support future decisionmaking by those planners, the panel focused primarily on basic, or exploratory, research from which cutting-edge discovery, invention, and innovation might emerge, although the panel also examined, to some degree, applied research and technology development—the other two components of science and technology (S&T). The panel focused on the following question: "How can the Army get the best long-term value from its investments in basic research?"

Most of the recommendations made by the panel and documented in this monograph are within the Army's power to execute. However, some will need the support of the U.S. Department of Defense (DoD) and even Congress. The panel believes that the large uncertainties in the threat that the nation will face in the coming decades make it imperative for the Army to improve the quality of its basic and applied research.

This research was sponsored by the Director for Research and Laboratory Management within the office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology and focused on the laboratories and research, development, and engineering centers (RDECs) run by Army Materiel Command (AMC).

[1] Although the expert panel did not have a formal name, for the purpose of this report we will refer to it as the Panel on the Future of Army Laboratories.

Panel Composition and Methods

A panel approach was directed by the research sponsor, who also approved the panel chairman selected by RAND Arroyo Center management. The Panel on the Future of Army Laboratories consisted of people who have spent their careers in research and managing research; or in the acquisition arena, where they oversaw or were consumers of research; or both. The panelists have experience in the Army, the U.S. Department of Energy (DOE), academia, and the private sector.

The panel's approach was to focus on collecting and examining available data that would reveal national trends in basic research and R&D, both federal and in the private sector, including the trends in investment in basic research and S&T and the pool of scientists and engineers (S&Es) that could be employed in these fields. The panel also examined trends in DoD's basic research and S&T funding, including the Army and other services. In particular, the panel focused on trends within the Army S&T establishment—the Army research labs and RDECs.

To get at the issue of the quality of basic research in the Army, the panel examined several laboratories known for their high-quality basic research: the three DOE nuclear weapon labs (Los Alamos, Lawrence Livermore, and Sandia National Laboratories), the Naval Research Laboratory, and AT&T's now-extinct Bell Laboratories. These labs have or had somewhat different missions than the Army's laboratories and RDECs and they operate or operated in different environments. But the environments that these labs created to stimulate high-quality basic and applied research provide some insights into how the Army might structure and fund its labs to improve the quality and value of its basic research.

The panel collected data from a variety of sources, reviewed relevant documents and reports, reviewed other laboratories for reference, and interviewed current and former researchers and leaders of Army laboratories and laboratories outside of the Army. The interviews were conducted on a non-attribution basis, so that the panel could receive the most candid information possible. RAND provided additional data collection and support for the panel to consider.

Findings

The Panel on the Future of Army Laboratories found—based on its analysis of data collected, the information gleaned from interviews, and reviews of the best basic research laboratories, as well as the panel members' collective experience in leading and managing research organizations—the following:

1. The environment for national and DoD research suggests the following:
   a. The United States, through the 20th century and the first few years of the 21st century, has led the world in basic research, but globalization could challenge this lead.

   b. Government-sponsored basic research has been critical to U.S. leadership in research, with DoD being a significant contributor.
   c. National defense has relied heavily on both nongovernment basic research and DoD-sponsored research to meet its needs.
   d. A reduction in DoD basic and applied research resources and also in nongovernment-sponsored basic research is forecast.
   e. Long-term defense capability, particularly in land warfare, will diminish considerably without a healthy basic and applied research effort.
2. Basic research should expand fundamental scientific knowledge that may lead to future warfighting capabilities. The Army needs a high-quality, inquisitive, agile basic research program with a long-term time horizon, in part because geopolitical futures and the needs of the future Army are uncertain.
3. The S&T domain is a continuum of discovery, knowledge, invention, innovation, technology development, and technology demonstration, with feedback cycles. It is often not a simple sequential process whereby an idea is started in basic research, migrates to applied research, and then transitions to technology demonstration.
4. The AMC basic research program is increasingly too near-term in its focus, with declining discovery and invention. In particular, the panel does not find mechanisms that stimulate staff to undertake high-risk but potentially transformational research in areas relevant to the Army.
5. Failure avoidance has grown to the point that research projects are expected to produce a product in addition to providing scientific knowledge. This has created a research, development, and acquisition (RDA) culture that trends toward conservative risk management at the expense of discovery, invention, innovation, and agility.
6. The Army S&T resources (funding, people, and facilities and equipment) database does not permit the necessary analysis and insights required by the Army S&T leadership to execute their policy, strategic, planning, oversight, and program defense responsibilities.
7. The metrics and data actually used by the Army Research Laboratory (ARL) for basic and applied research planning or evaluation are not apparent. There is a lack of metrics that allow ARL to track how the technology it develops is incorporated into new and modified systems. Thus, AMC cannot determine the return on its investments over the past 25 years, as evidenced by projects that eventually yield products and capabilities that are fielded.
8. The amount of basic and applied research funding available for the ARL Director to invest at his or her discretion, based on his or her local knowledge and capabilities, is far too low—below the 10 percent recommended in Chapter Five and Table 5.1 of this report. The ARL Director's Research, Quick Response, and Strategic Technology Initiatives are budgeted at only $7 million annually, from a core research budget of $174 million for in-house research in 2009.

Approximately 75 percent of ARL's core applied research funding is committed to Army technology objectives (ATOs) and technology program agreements (TPAs).

9. The share of the Army's basic research funding allocated to In-house Laboratory Independent Research (ILIR) has been declining since 1997 and has fallen below the 5 percent guidance from the Office of the Secretary of Defense (OSD) and the 5–10 percent goal recommended by the 1983 Packard report.[2]
10. Technical talent and management attention is a finite resource and must be managed accordingly. The panel finds that too much of ARL technical staff time and management attention is devoted to the pursuit of funding from external clients at the expense of leadership of ARL personnel and management of mission-funded basic and applied research. While work on applied research (Budget Activity 6.2) and advanced technology development (Budget Activity 6.3) projects is a valid sign of connection to the ultimate customer and of understanding of customer needs, the amount of basic research (Budget Activity 6.1) must be balanced accordingly and not neglected.
11. The recruiting, selection, career management, and development of S&Es requires more attention and innovation if the Army is to attract, retain, and mentor the staff necessary to meet its needs and perform high-quality S&T. The Personnel Demonstration Project, with its innovative provisions tailored to the scientist and engineer, is a demonstrated success at attracting and retaining good staff, reducing the time to fill openings, and permitting the lab to move in new directions more easily.[3] These features are vital to the quality of research organizations such as ARL and the Army Research Office (ARO).
12. The Army has not expanded its S&E workforce rapidly enough in the fast-changing research area of network and information sciences, where major breakthroughs continue to occur.
13. The percentage of ARL (less ARO) PhDs is far below the 50 percent typically found at first-rate laboratories, such as the Naval Research Laboratory (NRL), Lawrence Livermore National Laboratory, and Los Alamos National Laboratory. The panel is also concerned about the low percentage of PhDs in the RDECs, which is only 2–5 percent at several of the RDECs.
14. The quality of research at ARL has steadily improved since its inception. However, the stature and extent of recognition of ARL research within the external research community have not improved commensurately. For example, there are currently no members of the National Academies at ARL. External recognition is important for attracting and retaining quality staff. As such, improving

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[2] *Report of the White House Science Council Federal Laboratory Review Panel*, 1983. ILIR funding is provided to the RDECs, but not to the ARL.

[3] The Personnel Demonstration Project was previously called the Laboratory Demonstration Program, and it is often referred to by that name.

ARL's standing requires significant attention from ARL and Army leadership. It also requires continuous tracking and assessment by research department leaders of the progress on research projects.

15. The list provided by ARL of major inventions during the past 25 years originating from ARL basic and applied research (not including ARO-funded research) was uneven, tended to be innovations rather than discoveries or inventions, and dated back beyond the last quarter century. Notable discoveries and inventions are an important output metric for a research organization. ARL's ability to tell its story in and out of government is vital to establishing its reputation, attracting high-quality staff, and demonstrating the value of its basic and applied research to the Army.
16. The ARL has neither metrics, nor an investment/modernization plan, nor a funding line for anticipated facilities and equipment needs. ARL does not know its facilities recapitalization rate. The Army funded modern ARL facilities at Adelphi and Aberdeen, Maryland, through the base realignment and closure (BRAC) process. However, the panel is concerned that investments and facilities are not being sustained at a rate that would make them competitive enough to attract new staff and flexible enough to move to new areas.
17. ARO has been placed organizationally under ARL, which reports to Army Research, Development and Engineering Command (RDECOM), which reports to the commanding general of AMC. This runs directly counter to the arrangements at the best research laboratories within and outside of government, where they report to the chief executive officer (CEO) or to the CEO through a chief technology officer (CTO). The panel observes that, given the long-range nature of research and how ARL has become increasingly near-term in its focus at the expense of discovery and invention, the benefits of placing ARL and ARO under a large intermediate command like RDECOM as opposed to reporting to the commanding general of AMC are not clear.

Recommendations

The Panel on the Future of Army Laboratories has developed, based on these findings, a number of recommendations that it believes will improve basic and applied research within the Army. (The numbers in brackets indicate the findings that correspond to each recommendation.)

1. The Army should establish a culture of discovery in basic research to encourage risk-taking and pursuit of opportunities with high potential, in part by providing incentives for experienced researchers to take greater risk in new areas of discovery. [2, 4, 8, 9, 10, 14, 16]

2. The Army should improve the quality of its basic and applied research by improving its agility to move into new areas quickly and to encourage and reward risk-taking by the research staff. [2, 3, 4, 15]
3. The Army should diversify its basic research portfolio and establish funding stability in order to restore a longer-term perspective for basic research planning. [2, 4, 9]
4. The Army should increase its S&E bench strength in the fast-evolving areas of network and information S&T, where the biggest advances are likely to come. Inspired senior scientists and technologists with vision will be essential in research as well as in the design, development, evaluation, and deployment of future systems. [12]
5. The Army should keep ILIR funding at or above 5 percent of the Army's 6.1 budget and execute it like the Laboratory-Directed Research and Development (LDRD) program at the DOE weapons labs, excluding taxing customers. [2, 9]
6. The Army should increase the amount of discretionary basic and applied research funding allocated to the director of ARL to 5 to 10 percent of its total basic and applied research budget, as recommended in the Packard report. ARL should not have more than 50 percent of its 6.2 mission funding obligated for TPAs and ATOs. [8, 10, 11]
7. The Army and DoD should institutionalize the Personnel Demonstration Project personnel management system and seek direct local hiring authority for S&Es. Lab managers should leverage this system to improve the quality of their staffing and the personnel flexibility in their organization. [11, 13, 14]
8. ARL should task a panel of distinguished scientists and engineers from outside the Army to identify the top 20 most important research inventions in the past 25 years from ARL (less ARO) and its predecessor organizations. This story should be captured in media suitable for distribution, to raise awareness among the R&D community in academia, industry, and government of the return on investment for ARL. This effort should be updated every five years. [14, 15]
9. The Army should continuously improve S&E quality, recruiting, and retention within a culture of merit via
    a. the vigorous use of internships, coops, postdocs, researcher mobility across budget categories, and training, exchange, and collaboration arrangements with industry and academia
    b. field training with operational units
    c. mentoring junior and new S&Es
    d. seeking external recognition of staff by encouraging publications, patents, and professional society fellowships. [11, 12, 14]
10. The Army should develop and fund a laboratory/RDEC recapitalization plan, including a recapitalization rate goal for each laboratory and RDEC that sustains the capital stock and technical equipment at a level commensurate with

world-class research facilities. This is intended to address the challenges of securing sufficient funding for capital equipment and facility construction. [6, 14, 15]

11. The Army-wide S&T resource database needs to be improved to support timely analysis and decisions for sound policy, strategy, planning, and program defense and oversight. [6, 7]
12. The Army should reconsider the reporting chain for ARL and ARO.
    a. The panel recommends that, at a minimum, ARL should report directly to the commanding general of AMC, as do the AMC major subordinate commands.
    b. Given the Army-wide nature of ARO, the panel recommends that ARO either (1) report directly to the Deputy Assistant Secretary of the Army for Research and Technology (DASA(R&T)) or (2) remain part of ARL except be under the operational control of the DASA(R&T). There is precedent for the recommended operational control, as the Army Research Institute is part of the U.S. Army Human Resources Command but under the operational control of the Deputy Chief of Staff, G-1. [4, 8, 9, 14, 17]