

ARMY RESEARCH LABORATORY



**Making Department of Defense Basic Research Purple
(Joint), but NOT the Department of Defense Laboratories**

by Paul N. Barnes

ARL-TR-6762

December 2013

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14. ABSTRACT Fundamental research in the various services laboratories is divided into two categories for the Department of Defense (DOD): basic research (more exploratory, scientific basis orientated in nature) and applied research (more application-minded, engineering oriented in nature). DOD has conducted a number of studies over the years with a finding that basic research must be unfettered and better coordinated in the services. Early on in 1989, the Defense Management Review Decision (DMRD) 922 considered central management of all science and technology activities. However, some reports suggest an advantage of separate service laboratories is to ensure technology is developed toward the differing service needs. This report contends that syncing these two concepts will allow the most productive research with the greatest efficiency. This can be accomplished by separating out basic research from applied research; basic research activities should be made joint and the applied research should remain in the separate services. In general, the DOD laboratories remain with their respective services, but basic research becomes centrally managed. This report discusses the advantages and disadvantages of doing so, but ultimately the advantages outweigh the disadvantages of this realignment of research activities. The desired free-flow of information, establishment of world-class research, and trust in our premiere scientists are additional issues supporting this alignment in as well as the advantages discussed in this report.					
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Preface

Dr. Paul N. Barnes is currently the Chief of Power Components in the U.S. Army Research Laboratory (ARL) as a civilian and as Colonel Paul N. Barnes, the Deputy Director of Technology Integration in the Office of the Under Secretary of Defense (Policy) as a reserve colonel in the Air Force. He has previously spent 20 years at the Air Force Research Laboratory (AFRL) and is a fellow of that organization with several scientific honors and patents.

1. Introduction

The United States (U.S.) Military is arguably one of the most technologically sophisticated armed forces in the world. It typically makes use of this technical superiority in modern warfare both in tactics and strategic planning. All this technical sophistication is the result of basic research previously conducted from all sources, whether by government, academic, industrial, or foreign institutions. Basic research leads to applied research and subsequently to advanced technology development, especially in defense related technologies when considering the military end application. As a result, it provides either new or improved military functional capabilities.

The laboratories and testing centers in the Department of Defense (DOD) are a primary source of this technological innovation. A large number of facilities within each of the three services—the U.S. Air Force, the U.S. Navy, and the U.S. Army—are dedicated to providing the U.S. Military with its technological strength through research, development, test and evaluation (RDT&E) centers. Although the U.S. Marine Corps (USMC) has activities in RDT&E, they are largely provided by the U.S. Navy.¹ Figure 1 provides a distribution of the DOD laboratory workforce of scientist and engineers as classified by the services.² The Assistant Secretary of Defense for Research and Engineering, Mr. Lemnios, provided the following:

“This footprint includes 67 DOD laboratories dispersed across 22 states with a total workforce of 60,000 employees; 35,400 of whom are degreed scientists and engineers who conduct DOD-relevant research leading to key technology demonstrations and publish thousands of reports and peer-reviewed technical papers (1, 2).”

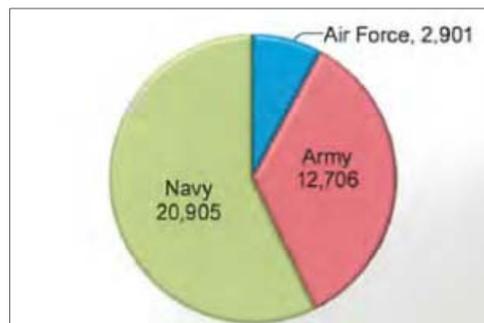


Figure 1. Laboratory scientific and engineering workforce as classified by the services (3).

¹This report is particularly focused on basic research, which is exclusively provided by the U.S. Navy for the USMC.

²Classification standards across the services are not necessarily uniform.

The fundamental research aspect of DOD’s technology development falls within the research and development portion of the RDT&E activities. In-house basic research is conducted within the U.S. Air Force, Navy, and Army corporate research laboratories, respectively called the Air Force Research Laboratory (AFRL), the Naval Research Laboratory (NRL), and the U.S. Army Research Laboratory (ARL). These laboratories both perform and programmatically manage basic research with the exception of NRL, where the management of basic research programs is principally done by the Office of Naval Research (ONR). For a perspective, basic research accounts for roughly 15% of the science and technology budget (4) and 2% of RDT&E (5).

A major concern is that the use of the term “basic research” means different things to different people. Some would view all research conducted within AFRL, NRL, and ARL as basic research with the terms fundamental research and basic research meaning the same thing. However, my use of the term basic research is more restrictive, where less than half of the work performed in these labs is basic research. The easiest division is simply by the RDT&E budget activities designated in the DOD Financial Management regulation as 6.1 (basic research), as opposed to 6.2 (applied research), or 6.3 (advanced technology development) funded work (6). See table 1 for an overview of the different budget activities. For those involved in DOD research, it is understood that there are larger-than-expected gray areas between 6.1 and 6.2 research and development as also with 6.2 and 6.3 research and development. The use of the 6.1 budget activities as the definition of basic research for this report makes a clean cut that is readily identified as an acceptable division of the work.³

Table 1. RDT&E Budget Activities (7).

Budget Activity	Title	Abbreviated Description
6.1	Basic Research	Systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications in mind.
6.2	Applied Research	The systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.
6.3	Advanced Technology Development	It includes all efforts that have moved into the development and integration of hardware for field experiments and tests. The results are proof of technological feasibility and assessment of operability.
6.4	Demonstration & Validation	It includes all efforts necessary to evaluate integrated technologies in as realistic an operating environment as possible to assess the performance or cost reduction potential of advanced technology.
6.5	Engineering & Manufacturing Development	It includes those projects in engineering and manufacturing development for Service use but which have not received approval for full-rate production.

³I acknowledge that there will be many who wonder why the effort was spent to discuss this issue and had not just simply stated 6.1 research. The discussion is for those who did not wonder.

Dr. Rees, the Deputy Under Secretary of Defense for Laboratories and Basic Sciences, provided the following:

“Basic research is systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts *without specific applications towards processes or products in mind... It is farsighted high payoff research that provides the basis for technological progress* (5).”

In an Under Secretary of Defense for Acquisition, Technology, and Logistics memorandum dated May 24, 2010, the following was clarified:

“‘Fundamental research’ means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons (8).”

The separation of basic research from the services into a consolidated laboratory in the DOD is a contentious subject. Discussions in the past were generally centered on the services laboratories of AFRL, NRL, and ARL dealing with the fundamental sciences. It is important to state this upfront: that is not the viewpoint of this report. It is specifically focused on a subset of these laboratories that deals with the 6.1 basic research.

2. Background

2.1 Previous Studies

The concept of DOD laboratory consolidation is not new. In 1989, the Defense Management Review Decision (DMRD) 922 included this as a possibility (9). The report was based on a consideration of how the various RDT&E development activities in the military services could increase efficiency and reduce the cost of their operations, especially through consolidation. Two primary alternatives were considered in DMRD 922:

- A Tri-Service Science and Technology Reliance Program that became referred to as Project Reliance.
- An overarching DOD laboratory to centrally manage and operate all DOD science and technology activities (not just basic research).

The latter choice would be a radical change resulting in each of the services ceding a portion of their “territory.” As a report from the Office of the Inspector General put it, “Concerned about

perceived risks associated with the second alternative, the Deputy Secretary of Defense approved implementation of Project Reliance, even though the second alternative might result in significantly higher savings (10).”

Different reports and reviews over the years continued to debate how to make the DOD laboratory system as operated by the separate services more effective and efficient (11). These studies were often focused on the laboratory units and facilities, as opposed to basic versus other research. As a relevant example, a Federal Advisory Commission on Consolidation and Conversion of Defense Research and Development Laboratories was established to provide recommendations on how to improve DOD laboratory operations in 1991. This commission stated, “The laboratory types within each Service are a function of that Service's weapons systems acquisition structure. There is no need to force the Service laboratory systems into a single model (12).” However, the commission specifically said that it is considering how best to achieve the attributes of an effective laboratory within the current environment and whether conversion to a government-owned, contractor-operated model was necessary or feasible.

In 1997, Vision 21, *The Plan for 21st Century Laboratories and Test and Evaluation Centers of the Department of Defense* had three main pillars of (1) Reduction, (2) Restructuring (intra-Service and cross-Service), and (3) Revitalization to attain a modern, efficient, and effective laboratory. However, cross-Service restructuring was clarified later in the report as, “an emphasis on cross-Service reliance” as opposed to consolidation of certain research activities at the DOD level (13). Recently in 2010, the Defense Science Board (DSB) was charged to validate the quality of the DOD basic research program and to provide advice on long-term basic research planning and strategies for the DOD (14). Although laboratory consolidation was not a consideration of the DSB, it did provide a final report in 2012 with recommendations on how to improve basic research, as well as summarizing findings from previous studies. A report such as this will be useful when considering the effects, both desired and consequential, of any restructuring of basic research.

2.2 Value of DOD Basic Research

An important point to mention is the value of DOD laboratories being involved in basic research. Some may contend that the quality of the research in DOD facilities has declined sufficiently that the task should simply be taken over by academia or industry. More likely than not, those institutions would be quite willing to perform this task for DOD; however, this would not be in the military’s best interest. “It was strongly believed by the executives that such a turn of events would clearly not be in the Nation’s best interest (11).”

A critical, but secondary, role DOD researchers perform is as honest brokers for the department allowing the military to be a smart-buyer. DOD researchers are especially in tune with the military needs since they are inevitably more versed in its needs (15), even if doing unfettered exploratory research. Acquisition officials and program managers often do not possess the necessary technical skills for a full and proper evaluation of the research and development

proposals. With subject matter experts present in the DOD laboratories, these researchers can provide unbiased reviews and recommendations for them. “It was strongly believed that having this in-house capability significantly improved the likelihood that the DOD would avoid costly acquisition mistakes (11).”

As it currently stands, most of the basic research sponsored by DOD is performed outside of the service laboratories. A rough distribution of basic research funds (6.1) is 60% to academia, 30% to government laboratories (primarily the service labs), and 10% to industry. A National Research Council (NRC) report indicated that the value provided by these activities can be categorized as follows:

- Expansion of the technical knowledge base supporting DOD’s needs,
- Creation of new technology options,
- Creation of a cadre of technical experts to provide expert advice,
- Recruitment of skilled technical people into the DOD for key positions, and
- Insight into future technology potential and military applications (16).

3. The Current Environment

To consider how basic research should be handled, there are a few issues associated with the current environment that will be pointed out in the next few subsections. These sections are intended to highlight the particularly relevant background issues that should be considered in either creating a joint basic research entity or not.

3.1 Free Information Flow

On May 24, 2010, the Under Secretary of Defense for Acquisition, Technology and Logistics issued a memorandum to the secretaries of the military departments saying:

“I have determined that additional clarifying guidance is required to ensure the DOD will not restrict disclosure of the results of fundamental research, as herein defined, unless such research efforts are classified for reasons of national security or as otherwise required by applicable federal statutes, regulations, or executive orders (8).”

One reason to do so was not just the advantages of the free flow of information, but the belief that it will encourage scientists and engineers to perform research in areas of importance to DOD (1). This was placed into a DOD Instruction with the intent to maximize the free flow of DOD scientific and engineering information to the public, while being consistent with applicable laws and regulations (17). Just this year, the free flow of research information was reinforced by the

White House when the Director of the Office of Science and Technology Policy issued a memorandum to the heads of the executive departments and agencies regarding, “Increasing Access to the Results of Federally Funded Scientific Research (18).”

The NRC advocated this position in its 2005 *Assessment of the Department of Defense Basic Research*, which was sponsored by DOD. The NRC even claimed that restrictions and export controls on research information derived from 6.1 funding of universities “disqualify it from being considered basic research as defined by National Security Decision Directive 189 and threaten to change fundamentally the open and public character of basic university research (16).” The NRC expressly stated that it did not apply to 6.2 funded university research. In the report’s recommendations, the NRC raised an associated issue with this freedom in its recommendations, expressly how basic research should be viewed (16):

“The Department of Defense should abandon its view of basic research as being part of a sequential or linear process of research and development (in this view, the results of basic research are handed off to applied research, the results of applied research are handed off to advanced technology development, and so forth). Instead, the DOD should view basic research, applied research, and the other phases of research and development as continuing activities that occur in parallel, with numerous supporting connections among them (19).”

They further stated that DOD needed to more openly make 6.1 basic research unfettered exploration and not tethered to short-term needs. Many cite the tethering aspect responsible for the decline in status of DOD laboratories. However, this is a contentious point. Those of the opposite opinion tend to express the following:

“In light of OMB initiatives and the Government Performance Results Act of 1993, the DOD should restrict research program metrics to those that are linked to well-defined milestones in support of Defense Technology Objectives or Joint Warfighting Capability Objectives. Not only will this allow program managers to monitor and assess the progress of the research, but it will allow for the phasing-out of a program once the stated ends are met or eliminating it if the research effort falls short of expectations.”

3.2 World-Class Research

Another general consensus is to make the DOD laboratories world-class research institutions. It is accepted that world-class research will provide top-rate solutions and information. The problem at DOD laboratories was well-phrased by an AFRL Chief Technologist that the “[q]uality and quantity of intramural S&T work is not uniformly strong (20).” In general he outlined this effort as “plans, people, and processes.” A hard question to answer is how to specifically accomplish this in DOD. A yet harder issue to handle is to either accurately identify the consequence of actions that are preventing this from being more fully achieved or willingly

accept the necessary actions that will cause this to be more fully achieved. Of particular importance to establishing world-class research is attracting and retaining top scientists and engineers (S&Es) (people) and having high-quality research (processes), especially with many great plans in abundance. These two issues are interlaced. The Assistant Secretary of Defense for Research and Engineering summed this as follows:

“In order to increase the effectiveness and value of the Department’s basic research program, the research and engineering enterprise has redoubled efforts that: attract and inspire the best scientists to engage problems of defense importance, and to enable those scientists to better interact with developers and users; improve management practices and policies to enhance productivity and enable scientists to better communicate and collaborate; identify emerging areas of science with the potential for significance to defense capabilities; and focus DOD basic research on specific domains of defense interest, and on transformational scientific opportunities (1).”

To make the research in DOD laboratories more “uniformly” world-class does not mean that each and every scientist or engineer is the best in the world. Dr. Hans Mark, a former Director of Defense Research and Engineering stated, “The presence of a few individuals of exceptional talent has been responsible for the success (and even the existence) of outstanding research and technology development organizations (21).” Industry also acknowledges the value as stated by an executive vice president at 3M Corporation, “An outstanding researcher is worth 4 or 5 times more than the average scientist (22).” Exactly what fraction of the work force should be explicitly highly distinguished researchers is not exact, but one study ventured, “There is evidence that suggests the figure is probably around 10% of the technical workforce for a laboratory whose primary mission is fundamental research (22).”

In the recent past, NRL offered a great example of attracting talent. NRL was able to do this even though private industry could offer a significantly better financial compensation. DeYong clarified how NRL accomplished this, along with what should not be done:

“This success was achieved by maintaining sufficient tangible income and superior intangible benefits such as important work, reasonable autonomy, state-of-the-art equipment, and high-quality colleagues. However, bureaucracy has eroded these benefits (for example, long delays in facility modernization), and tangible income has become insufficient for attracting and retaining enough of the best (23).”

A lesson can also be learned from a previous Air Force program known as Palace Knight. Top students were promised world-class facilities at AFRL to do world-class research. Many soon left AFRL with the complaint of being tasked to do program management either partially or fully (24). Some, ironically, transferred to NRL. Interestingly, “Insights to A Great Career” by AFRL lacks examples of scientists and engineers on the technical expert path (25). While this problem

of program management versus in-house research may be more applicable to AFRL, there is the larger issue of seemingly vast bureaucratic requirements imposed on DOD researchers. The phrase used within the 2005 Defense Science Board Task Force was the “death of a thousand cuts (14).”

A study entitled *Science and Technology Community in Crisis* provided a list of the eight characteristics it considers associated with a world-class laboratory, along with a detailed discussion of each item (22). These are:

1. Outstanding People: The Key to a “World-Class” Laboratory
2. State-of-the-Art Facilities and Scientific Equipment
3. Important and Challenging Work
4. Adequate and Stable Funding
5. Visionary Leadership
6. Reasonable Autonomy
7. Pride in Public Service and Institutional Pride
8. Adequate Technical and Laboratory Support

3.3 Service Laboratory Comparison

As previously mentioned, in-house basic research and program management activities within the DOD are performed principally by AFRL, NRL, ONR, and ARL. There is some additional 6.1 funding in the Defense Advanced Research Projects Agency (DARPA), but not significant (16). Because the lab activities are controlled by their respective service, effective and efficient coordination can be a challenge. This has resulted in the instituted oversight activities by the Office of the Secretary of Defense (OSD). Within the services, basic research is managed differently as explained in the next few paragraphs.

In the Air Force, all basic research funding is budgeted through the Air Force Office of Scientific Research (AFOSR), a suborganization of AFRL. The research directorates in AFRL are somewhat unique in how it is structured compared to other laboratories in general. Its primary effort, based on the distribution of funding, is the management of external programs. As such, AFRL also has a larger number of personnel in its organization. In-house research is mixed with program management down to the branch level with few exceptions. The AFRL mixture results from its arrangement into technology directorates, mainly by application as opposed to science, each with a distinct mission. In-house Research and external programs are created in support of the unique subunit’s mission and coordinated with others.

The Navy has NRL for in-house research and ONR for program management of extramural basic research. However, in contrast to AFOSR, ONR also oversees and manages applied research and

advanced development science and technology funding for the Navy. ONR is not a suborganization of NRL and NRL is typical of what one would expect for a laboratory with relatively minimal program management responsibilities for external contracts.

The Army is different yet and presents a more complicated management structure. Similar to AFRL, extramural basic research funding is principally managed by the Army Research Office (ARO) although not strictly. ARO is also a suborganization of ARL. However, all Army basic research funding is budgeted through the Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASAALT), which typically does not directly manage these funds. ARL receives in-house basic research funds directly from ASAALT and a portion of those funds may go to extramural research. Additionally, policy guidance is provided by the Deputy Assistant Secretary for Research and Technology (14). ARL is closer in research activities to NRL than AFRL in that it primarily consists of in-house researchers with few program managers as part of its organization.

3.4 Trusting the Researchers

A common concern expressed by managers of S&Es is the S&Es playing in a sandbox if left to themselves. President George W. Bush stated:

“To keep America competitive into the future, we must trust in the skill of our scientists and engineers and empower them to pursue the breakthroughs of tomorrow (26).”

Expanding the use of that trust is important. Although people are not perfect and management is necessary to operate most effectively and efficiently, it should not be assumed the researchers will by nature want to “play in a sandbox” when it comes to research. As stated in a DOD report:

“Furthermore, basic research program managers do a good job of coordinating their respective portfolios across DOD. The performance of excellent program managers acting on their own volition is most important, and the formal coordination mechanisms are a distant second in importance (14).”

Insinuated in select references (e.g., next quote) and based on the author’s experience, managers in the labs often have some technical background to include research, but in many cases their research record is rather average or even mediocre. While not incompetent in the management of science, they often lack the ability to understand diligent progress in quality basic research, relying on metrics to compensate for their lack of technical prowess. This results in acceptable—but not stellar—management and likely causes the uncertainty in managers when determining whether a researcher is truly playing in a sandbox or not. A former NRL director espoused the importance of technical excellence in selecting leaders in the organization:

“His priority was to select the person with the best technical qualifications. He believed that these people were paid for making the sound technical decisions and

to provide scientific and technical leadership. The more administrative and procedural matters could be handled by a well-trained office staff (11).”

On a similar note, a comment from the 2005 NRC Report on the *Assessment of DOD Basic Research* was made regarding the differing structures in the services for managing basic research:

“Each of these approaches has strengths and weaknesses, and the committee found no reason to recommend one approach over another. Instead, the committee concludes that the key to effective management of basic research lies in having a cadre of experienced, empowered, and respected 6.1 program managers, supported by uniformly understanding senior leadership deeply committed to basic research (16).”

4. Making Basic Research Purple

From one viewpoint, the debate of joint basic research or service-lead basic research is similar to issues associated with centralized *versus* dispersed research activities. “This dichotomy is familiar in other organizations, including for-profit corporations (15).” This does not discount the unique environment of the DOD that must be taken into consideration, just as it does not discount the unique environment of other organizations. The current environment in which DOD operates suggests making basic research purple will provide not only the most effective and efficient use of resources, it will also provide the greatest productivity for the DOD in technological advancement.

4.1 Disadvantages of Joint Research

The primary reason for maintaining basic research separately as service-lead activities is that the services can then customize the associated programs directly to the service’s needs. Having a direct responsibility for basic research, each service will have a sense of ownership and vested interest in what is accomplished. If basic research is made purple, it is then possible that the research would become disconnected from the services and would evolve into a “collection of sand-box activities. While all this could be avoided by proper management, it is a danger (15).”

There are those who advocate the colocation or even combination of basic and applied research. Per one report:

“In some disciplines, basic and applied research are tightly linked, and the proximity available in a large laboratory environment can facilitate advances. Opportunities for collaboration and an integrated approach can make the Service laboratory a more attractive place for all researchers (14).”

One of the primary drivers for consolidation of the laboratories in the past (not necessarily just basic research) is to avoid duplication and increase the synergy of the separated research, especially since oft times the development can benefit more than a singular service. However, this does not mean that the service laboratories cannot work together in harmony through means such as the Project Reliance concept that was instituted in the past. Dr. Russo, a former director of AFRL, conveyed this about the program:

“The Project Reliance concept allowed the services to exchange ideas and share information regarding their technology development programs on a regular basis, and address issues of common concern. Russo believes that it is particularly important that Project Reliance succeed. He considers the idea of a single DOD corporate research laboratory or ‘purple laboratory,’ as it is sometimes called, to replace ARL, NRL, and AFRL, to be an unattractive alternative. Given the unique set of mission-related requirements for each service, Russo believes that it would be unrealistic to expect Air Force personnel, civilian or military, to have the same degree of confidence in a DOD wide laboratory as they have today in AFRL (11).”

It should be stated that while the existing system can be improved upon, it is not a disaster either. A recent report found the current DOD basic research program to be “a very good one, comparable to others in the federal government and well-suited to DOD's needs (14).” This report’s task force felt that the most significant improvement would be the reduction of the “bureaucratic burden” that exists in the laboratory system.

4.2 Advantages of Joint Research

In starting the discussion on the advantages of making basic research joint, the Reliance Project is a good place to start. Large bureaucracies (indeed the service labs are their own bureaucracy) will tend to resist dramatic change and prefer solutions that tweak the status quo. As stated in one report on DOD Science and Technology (S&T) “Senior S&T leaders typically defend current processes that no longer are effective (15).” It is possible that the Reliance Project was born more out of the desire to avoid laboratory consolidation than to enact real collaborative interchange. Progress by the interservice collaboration effort eventually curtailed as the pressure lifted from the DMRD 922 consolidation suggestion. In a panel held at the 26th Annual Precise Time and Time Interval Systems and Application Meeting in 1994, Dr. Frederick Betz of NRL shared some raw thoughts on its implementation:

“In reality, it kind of all started when the Office of the Secretary of Defense, back in 1990, prepared a draft memorandum that said that they would take over all Science and Technology (S&T) funding activities for the three services. Perhaps for the first and only time in history the three-service principal S&T flag officers stood up and screamed in unison ‘No, let us do it. Give us the rope and let us form our own noose that we may hang ourselves (27).”

“So they formed a Joint Directors of Laboratories, which is composed of the three principal S&T flag officers for the three-services panel to investigate how they could meet the Department of Defense (DOD) objectives, which were to eliminate redundancy, promote joint activity, and, of course, I guess the redundancy and the perception that everybody was going their own way in doing what they would like in research, science and technology, without any guidance ...

“That is kind of the history. We went on for about three years, as I remained on the Space Panel, and not doing any real planning (to a very large extent), but more or less documenting the execution of the funding of science and technology. There were not a large number of true joint programs developed, although there were a number of small programs; and there were a number of good relationships that developed between the three representatives of the three services, in their technical areas.

“When this Reliance was initially created, my lab director came back and told us what had happened. And basically, the pie supposedly got carved up in a way that the three services each had a significant activity and area, like solid state technology, for example. Then it became, I believe it was, the Category I Program, where each service will continue doing research in a certain area; and there will be very close collaboration; and ‘jointness’ was the key word; everything would be done jointly; that there would no Army solid state program or Air Force solid state program or Navy solid state program. All the programs shall be planned jointly and executed jointly, even though the funding might come from only one of the three services. So we were to be one big happy family, without the actual combination of the three services laboratories.”

With Project Reliance faded, the services eventually went their separate ways. Collaboration does occur between the different labs and some shining examples can be shown, but it is not consistent. With research programs separated as such, it is always more difficult to coordinate and to realize potential synergies. However, by combining the basic research into a joint lab, “The advantages of such an arrangement would be a greater mass of 6.1 research, more coherence across all of the Department's activities, and an easier recognition and facilitation of synergies (15).” An accomplishment in basic research in one service may very well have a greater relevance and benefit to another service’s program.

Another significant problem is the duplication of effort that occurs. This can even occur on a large scale as one service competes with another as evidence in the Army’s building and furnishing of a microelectronics research facility. This caused an audit by the Office of the Inspector General:

“Audit Results. The Army plans to build a major new laboratory facility and to procure new equipment for microelectronic (electronic devices) research that may be unnecessary and redundant to existing DOD capability. The Army may be

spending as much as \$306 million for new construction, equipment, and associated personnel related expenses (10).”

The Inspector General’s report even cited the DSB recommendation that “a single DOD Tri-Service corporate microelectronics facility should be capable of developing defense unique technologies and alleviate the deficiencies in industry and academia (10).” The DSB further stated in their report; “The Task Force concludes that investment to build additional corporate microelectronics research facilities is unwarranted.” In the end, the facility was built by the Army despite both reports.

Duplication of effort can also occur in extramural programs with an egregious example given in a Senate Report entitled, *The Department of Everything* (referring to the DOD) (28). In this case, a professor from Penn State University submitted nearly identical proposals for basic research funding to different agencies. Both DARPA and the Air Force funded the proposal as well as the National Science Foundation (NSF), all for the same exact project. It is not illegal or unethical to submit the same proposal to multiple agencies, only to accept funding from more than one for it. This case is particularly troublesome in that the professor sequentially submitted a proposal to the different agencies after receiving funding from each agency in sequence.

Pulling basic research out from applied activities has its distinct advantages, especially to keep it unfettered as discussed previously in the Current Environment section. Cleanly separating 6.1 funded activities from 6.2 activities (separation already exists in part at the service labs) does not mean a clean cut in basic research from applied research in the real-world science and engineering development. It was previously stated that there is a lot of gray area between the two. The near-term needs of the services results in management pressure to refocus basic research in support of those needs (16). A JASON⁴ study provided an interesting example of the issue from an intraservice perspective:

“We now have a new vision for the future, as expressed, for example, at the ONR website ... ‘*You may have noticed that our list of science and technology departments has changed. The Office of Naval Research is reorganizing to better align its resources toward achieving Navy and Marine Corps science and technology goals and capabilities.*’ In other words, ‘We know what we need (goals and capabilities)’ and implicitly ‘Funding is available for those who can follow instructions.’ The vision expressed by this statement (which is but one example from many) is a recipe for a mediocre future for the DOD and our society. If such policies had been in place in the first 40 years following World War II, many current military capabilities that are fundamental to our national defense would never have been imagined, much less achieved^[5]. Indeed, DOD

⁴JASON is not an acronym, although lightly inferred as "July August September October November" for the months in which the group would typically meet; it is a reference to a character from Greek mythology (from Wikipedia).

⁵Note that this point was earlier iterated as Finding 8 in National Research Council, *Assessment of the Department of Defense*

has largely eliminated basic research and redefined ‘product development’ as the new, improved version (15).”

Part and parcel of this is failure avoidance. Basic research is given the expectation to provide some tangible product, in addition to the scientific knowledge generated. “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 (29).” Dr. Coffey, a former director of NRL, felt that despite successes achieved in NRL, “NRL seemed to be in a constant ‘survival drill.’ Yesterday’s accomplishments and contributions were dismissed with the question, ‘but what have you done for me lately?’ It became clear that there was no way to ‘win’; rather one had to ensure that NRL ‘did not lose’ (11).”

Mixing basic research with applied research also has its disadvantages. When this is done in DOD, it is typically arranged as an application-oriented organizational structure. In-house research is typically directed to address the narrower mission of the application it is paired with, even if the application itself is a broader category, as opposed to any critical service requirement. When the owning unit’s need is met, the research is often revamped or terminated since the other external-unit requirement may be considered their problem to meet with their personnel. This can be true whether the external requirement is intraservice, or interservice in nature. However, establishing world-class research is not done overnight and, if it exists, it should be allowed to address all of DOD’s requirements.

A RAND report, commissioned by the Army to improve basic research, made the following observation (note that placing basic research under the direction of a single DOD structure may solve this issue):

“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 (29).”

5. Implementation

The advantages of assembling the different basic research entities throughout the DOD into a joint agency outweigh the disadvantages and should be done. It may require legislative changes to enable this recommendation if the most aggressive measures are taken. Since this may be recommending a dramatically different way of doing business, this next section provides possibilities of how this can be accomplished. This follows the line of not saying something is broken without suggesting how to fix it. Even so, how to make basic research joint is not the primary purpose of this report and as such the section simply shares constructs previously conceived, not to advocate or endorse any particular aspects.

DOD Instruction 3210.1 provides guidance for the governance of DOD basic research. It charges the Assistant Secretary of Defense for Research and Engineering to “provide technical leadership and oversight; issue guidance for plans and programs; develop policies; conduct analyses and studies; and make recommendations for DOD basic research (30).” This provides an initial place to start for organizational leadership. The funding can be provided by the services and DARPA. The total amount of funding is dictated to the services and DARPA, but the specific technology area is decided by them. In this way, the services and DARPA can specify the technical areas it sees as most relevant merely by shifting funds as deemed appropriate. If more than one invests in a given area, then that simply means an expanded research base in that area is necessary. If none provide funding to a given area, then a statement is being made. Even so, the joint basic research laboratory could be allowed to apply a minimal tax to allow certain research to continue if the “fettering” effect is a concern.

In a paper by Fountain, he advocates that the DOD labs should in general use the government-owned, contractor-operated model as used by the Department of Energy and the National Aeronautics and Space Administration. He states:

“The Department of Defense could follow the same approach with its service laboratories by contracting their management to universities or combining them into a Joint Research Laboratory under a single university’s management. Using this model, the Defense Department could have the best of both worlds by sponsoring research that is accountable to meeting stated Defense Technology Objectives and which also serves to meet more altruistic goals like encouraging students in scientific disciplines (19).”

The Joint Defense Capabilities Study proposed three alternatives (31). Only two of these alternatives are provided here since one is merely an enhancement of the present system. Note that the one solution suggests a greater vision of research being centrally controlled by DOD,

which is specifically not advocated here; however, this structure would apply only to the 6.1 basic research component with the 6.2 lab activities still nested in each of the services.

5.1 Centralized Funding and Centers of Excellence (31)

An aggressive approach to RDT&E reform would be to centrally manage resources by Integrated Process Teams (IPTs). This would be in a more rigid structure than previously done with the Reliance Project. The DOD-level and service RDT&E executives who control the research and development resources would work with the Assistant Secretary of Defense for Research and Engineering (ASDR&E) (formerly DDR&E) to provide innovative technology solutions through representation on different capability teams. Centers of Excellence (COEs) would be established within the current DOD/Service laboratory resources to concentrate research and development efforts in specific areas. The COEs would include the universities doing defense funded basic research. Although specialized, COEs could invest in several related technology areas allowing overlap to provide competition and divergent views. The COEs may have differing governance options—such as government-owned, contractor-operated (one example only)—that will be best suited for the given COE mission.

5.2 Central DOD Lab System (31)

A radical approach to RDT&E reform would go a step further than central management of all resources between DOD-level and service RDT&E executives and the ASDR&E (formerly DDR&E) in an IPT process. The COEs would be established within a central laboratory system to concentrate research and development in specific areas. A single Office for Basic Research with a DOD Research Laboratory would manage and execute all basic research for DOD. This realignment of the RDT&E structure and the loss of service control of certain RDT&E resources could require legislative changes to authorize a DOD Office of Basic Research and Laboratory as well as a potential change in reporting authority within ASDR&E. See figure 2 for a slide from the Joint Defense Capabilities Study that depicts this situation.

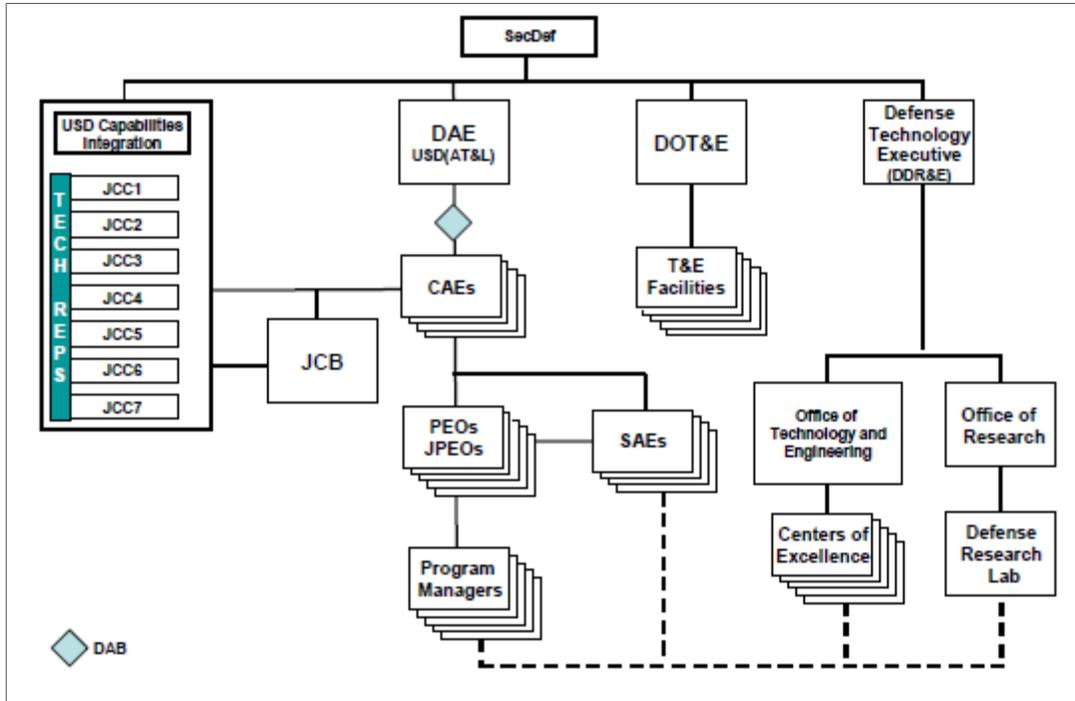


Figure 2. A proposed organizational chart for a central DOD Laboratory System (31).

6. Summary and Conclusions

Basic research in DOD spans, “(1) discovery arising from unfettered exploration, (2) focused research in response to identified DOD technology needs, and (3) assessment of technical feasibility (16).” It is found principally at AFRL, NRL, and ARL, but can be located elsewhere such as DARPA and as provided by ASAALT. A comparison of the services’ fundamental labs allows an examination of the different effect organizational constructs have on research. In addition, a number of studies and reviews have been conducted by DOD on basic research. DMRD 922 proposed central management of all science and technology activities, while other reports suggest it is more advantageous to leave basic research to the separate services. Incorporating the fundamental philosophies of these two concepts to achieve the most productive research with the greatest efficiency requires that basic research be separated out from the services as a centrally managed operation under DOD. As such, the core DOD laboratories essentially remain with their respective services.

Although a contentious subject, basic research must be separated from the services into a DOD joint laboratory. There are several issues in the current environment that speak to this point: the free flow of information, the desire for world-class research, and the need to trust researchers to do the right thing. The issue of centralized versus dispersed research activities is faced in other organizations, including for-profit corporations. It will require a major reorganization with

resources scattered across multiple locations and will initially be difficult to manage. However, the greater payoff inevitably comes via the more difficult path. There will be strong resistance to this as it represents a complete cultural change and may place the leadership and subordinates temporarily in turmoil (32). However, over time groups would ultimately relocate for ease of research integration and management.

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8. List of Symbols, Abbreviations, and Acronyms

AFOSR	Air Force Office of Scientific Research
AFRL	Air Force Research Laboratory
ARL	U.S. Army Research Laboratory
ARO	Army Research Office
ASAALT	Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology
ASDR&E	Assistant Secretary of Defense for Research and Engineering
CEO	chief executive officer
COE	Center of Excellence
CTO	chief technology officer
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DMRD	Defense Management Review Decision
DSB	Defense Science Board
IPT	Integrated Process Team
NRC	National Research Council
NRL	Naval Research Laboratory
NSF	National Science Foundation
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
RDA	research, development, and acquisition
RDECOM	Research, Development and Engineering Command
RDT&E	research, development, test and evaluation
S&E	scientist and engineer
S&T	Science and Technology

USMC

U.S. Marine Corps

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