



ACQUISITION,
TECHNOLOGY,
AND LOGISTICS

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

JAN 25 2017

MEMORANDUM FOR: SEE DISTRIBUTION

SUBJECT: Final Report of the Defense Science Board Task Force on Defense Research Enterprise Assessment

The attached report contains the findings and recommendations of the Defense Science Board (DSB) Study on Defense Research Enterprise Assessment. The 2015 National Defense Authorization Act directed the Secretary of Defense to task the DSB to conduct an assessment of the organization, missions, authorities, and health of the defense research and development enterprise. This study assessed the condition of the Department of Defense (DoD) research and development enterprise.

The Task Force found that, in an era of globalization, the engineering centers and warfare centers ("the Labs") continue to fulfill vital missions on behalf of the Warfighter. This DoD research enterprise is characterized by high-quality science, technology transition, and smart acquisition. The rapidly changing technology landscape means that the Labs also must adapt their mission to continue to serve and ready themselves for their evolving needs of the Warfighter.

I approve the public release of this report, which proposes recommendations for the following areas: missions, operating models, organization, workforce, infrastructure, and collaboration between DoD laboratories. Since the Labs operate in a rapidly evolving environment, the report recommends expanding their missions to maintain value proposition. This includes promoting open innovation and technology defense in order to effectively lead DoD through fundamental technology shifts by anticipating the emerging requirements of the Warfighter.

Please review the report findings and recommendations. I am interested in receiving your feedback for inclusion in programs wherever these technologies and initiatives can be applied. I request comments, either formally or informally, within the next 90 days. My point of contact is Ms. Karen Saunders at osd.pentagon.ousd-atl.mbx.dsb-office1@mail.mil or 703-571-0079.

James A. MacStravic
Performing the Duties of the
Under Secretary of Defense
for Acquisition, Technology,
and Logistics

Attachment:
As stated

DISTRIBUTION:

SECRETARY OF THE ARMY

SECRETARY OF THE NAVY

SECRETARY OF THE AIR FORCE

CHAIRMAN OF THE JOINT CHIEFS OF STAFF

UNDER SECRETARY OF DEFENSE FOR POLICY

UNDER SECRETARY OF DEFENSE FOR INTELLIGENCE

COMMANDANT OF THE MARINE CORPS

COMMANDER, U.S. AFRICA COMMAND

COMMANDER, U.S. CENTRAL COMMAND

COMMANDER, U.S. EUROPEAN COMMAND

COMMANDER, U.S. NORTHERN COMMAND

COMMANDER, U.S. PACIFIC COMMAND

COMMANDER, U.S. SOUTHERN COMMAND

COMMANDER, U.S. SPECIAL OPERATIONS COMMAND

COMMANDER, U.S. STRATEGIC COMMAND

COMMANDER, U.S. TRANSPORTATION COMMAND

DIRECTOR, COST ASSESSMENT AND PROGRAM EVALUATION

DIRECTOR, OPERATIONAL TEST AND EVALUATION

ASSISTANT SECRETARY OF DEFENSE FOR LEGISLATIVE AFFAIRS

ASSISTANT SECRETARY OF DEFENSE FOR PUBLIC AFFAIRS

ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

DIRECTOR, NET ASSESSMENT

DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

DIRECTOR, MISSILE DEFENSE AGENCY

CHAIRMAN, DEFENSE BUSINESS BOARD

CHAIRMAN, DEFENSE POLICY BOARD

DEPARTMENT OF DEFENSE
DEFENSE SCIENCE BOARD

DEFENSE RESEARCH ENTERPRISE ASSESSMENT

January 2017



OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY AND LOGISTICS
WASHINGTON, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB). The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense.



DEFENSE SCIENCE
BOARD

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION,
TECHNOLOGY, AND LOGISTICS

SUBJECT: Final Report of the Defense Science Board (DSB) Task Force on Defense Research
Enterprise Assessment

I am pleased to forward the final report of the DSB Task Force on Defense Research
Enterprise Assessment, chaired by Dr. Victoria Coleman.

The study proposes recommendations in the areas of missions, operating models,
organization, workforce, infrastructure, and collaboration of the Department of Defense
laboratories, engineering centers and warfare centers ("the Labs"). The Labs operate in a rapidly
evolving environment and, in order to maintain their value proposition, the report recommends
expanding missions to include open innovation and technology defense while leading the
Department of Defense through fundamental technology shifts by anticipating the emerging
requirements of the warfighter.

I concur with the Task Force's conclusions and recommend you forward the report to the
Secretary of Defense.

A handwritten signature in black ink, appearing to read "Craig Fields", is positioned above the printed name.

Craig Fields
Chairman, DSB

THIS PAGE LEFT INTENTIONALLY BLANK



**DEFENSE SCIENCE
BOARD**

**OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140**

MEMORANDUM TO THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on Defense Research Enterprise Assessment

Attached is the final report of the Defense Science Board Task Force on Defense Research Enterprise Assessment. The Task Force assessed the organization, missions, authorities, and health of the defense research and development enterprise of the Department of Defense (DoD). The Task Force addressed:

- how well the defense laboratories anticipate and respond to the needs of the Department;
- the mechanisms that exist to refurbish and recapitalize DoD labs, and how the state of the infrastructure (both physical and research) compares with other Government, academic, international, and industrial counterparts;
- how well the DoD laboratories and centers (collectively referred to as “the Labs” in the report) attract, recruit, retain, and train its workforce to remain technically current and flexible to respond to emerging national requirements; and
- whether the appropriate balance exists between Service control and laboratory director discretion to maximize laboratory mission effectiveness.

The Task Force offers recommendations which address current and evolving missions of the defense research enterprise, laboratory operating models, culture, workforce, infrastructure, collaboration, and the relationship between the laboratories and Office of the Secretary of Defense (OSD) and Congress.

The Task Force found that, in an era of globalization, the Labs continue to fulfill vital missions on behalf of the warfighter. This DoD research enterprise is characterized by high quality science, technology transition, and smart acquisition. The rapidly changing technology landscape means that the Labs also must adapt their mission to continue to serve and ready themselves for their evolving needs of the warfighter. The Labs operate in the larger defense system not optimized for lab operations. The OSD must actively champion and support the Labs, and Congress must continue working with the Department to simplify the regulatory environment in which the Labs operate.

The Task Force concluded that in order to maintain and enhance the value proposition of the defense research enterprise, the Labs need to embrace open innovation and technology defense and

be more active in the DoD requirements process. The Labs must also lead the DoD through fundamental technology shifts by being able to anticipate and canvas emerging and future requirements and evolving missions. The DoD (i.e., the OSD, the Services, the Combatant Commands) needs to actively engage in the evolution of the lab enterprise as the Labs undergo the needed culture shift to utilize their existing authorities. Finally, expanded coordination among intermural basic research portfolios across the Labs without creating additional administrative burdens is required.

A handwritten signature in black ink, consisting of a series of fluid, connected loops and strokes, representing the name Dr. Victoria Coleman.

Dr. Victoria Coleman
Chair

Table of Contents

Foreword.....	1
1. Introduction	2
1.1 Key Messages	2
1.2 The Value Proposition of the Labs: A Proud Heritage of Defense Science and Technology	2
1.3 The Labs and Centers are Essential to the Warfighter.....	3
1.4 Task Force Observations	3
2. The Current and Evolving Mission of the Labs	5
2.1 Existing Lab Missions.....	5
2.2 A few examples of other key contributions	7
2.3 Findings	12
Delivering on Existing Missions.....	12
The Mission of the Labs is Evolving.....	13
Technology Leadership	14
Technology Defense.....	14
Open Innovation	15
Open Campus Example: Center for Research in Extreme Batteries	16
Technical Accomplishments.....	16
2.4 Recommendations Regarding the Existing and Evolving Lab Mission	17
3. Lab Operating Models.....	18
3.1 Working Capital Fund and Mission Funding	18
3.2 Comparison with Overseas Partner Labs, Federally Funded Research and Development Centers, Government-Owned, Contractor-Operated Facilities, and Private Labs.....	19
3.3 Lab Operating Model Recommendations	19
4. Lab Readiness: A Spirited Culture of Self-Reliance.....	20
4.1 Findings	20
Lab Culture	20
Authorities Granted but Not Exercised.....	20
Local Control for Local Matters.....	21
Measuring Performance for Success.....	22
4.2 Organizational Recommendations.....	23
5. Lab Readiness: Workforce	24
5.1 Findings	24
Talent Acquisition and Retention.....	24
Lab Demo Authority.....	25
Science and Technology Reinvention Laboratories	26

5.2	Workforce Recommendations	26
6.	Lab Readiness: Infrastructure	28
6.1	Findings	28
	Aging Infrastructure at Service Labs and Centers	28
	Funding Laboratory Infrastructure.....	28
	Enhanced Use Lease.....	29
	Infrastructure challenges	31
6.2	Infrastructure Recommendations.....	31
7.	Lab Readiness: Collaboration and Working with Others	33
7.1	Findings	33
	Collaborating with Each Other for More Effective Outcomes – Reliance 21	
	Communities of Interest	33
	Laboratory Quality Enhancement Program	35
	Working with the Defense Advanced Research Projects Agency	35
	Warfare Center to Laboratory Collaboration.....	35
7.2	Collaboration Recommendations	36
8.	The OSD and the Labs	37
8.1	Findings	37
	The OSD Better Buying Power 3.0 and the Labs	37
	Department Engagement with the Labs	37
	Advocacy for the Labs	37
8.2	Recommendations on the OSD and the Labs.....	38
8.3	Recommendations Recap	38
	Authorities Recommendations	38
	Navy Specific Recommendations	39
9.	Congress and the Labs.....	40
9.1	Findings	40
9.2	Recommendations on Congress and the Labs	42
10.	Conclusion	43
	Appendix A – Task Force Terms of Reference	45
	Appendix B – Task Force Membership	46
	Appendix C – Briefings Received.....	47
	Appendix D – Past Studies.....	50
	Appendix E – Section 219	52

Appendix F – Entrepreneurial Programs.....	53
Appendix G – NRL Sponsors.....	54
Appendix H – AFRL S&T Business Model	55
Appendix I – Major MILCON	56
Appendix J – FFRDCs and UARCs.....	57
Appendix K – Private Industry Laboratory Models.....	58
Appendix L – United Kingdom Laboratory Model	59
Appendix M – Australia Laboratory Model.....	60
Appendix N – Acronyms and Abbreviated Terms.....	61

THIS PAGE LEFT INTENTIONALLY BLANK

Foreword

The Department of Defense (DoD) laboratories, engineering centers, and warfare centers were created to inform and enable effective defense acquisition and serve as a reach-back capability by providing technology options, possessing unique facilities and infrastructure, and maintaining a superior workforce comprised of technical experts in areas with relevant military applications.

In the ensuing decades since the end of the Cold War, much has changed in the threat environment our military operates, and even more has changed in the technology arena. Rising commercialization and shrinking defense budgets mean that much of the technology the warfighter depends on will be built outside the defense perimeter rather than inside. Thus, the Labs play an even more important role both in retaining capability in areas where the private sector has no commercial interest and in ensuring that commercial solutions are adapted for warfighter needs.

The Defense Science Board (DSB) Task Force on Defense Research Enterprise Assessment, as instructed by the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) and Congress, focused on assessing the defense laboratories and engineering centers and warfare centers (referred to in this report collectively as “the Labs”) missions and their responsiveness to Department needs, their workforce and infrastructure challenges and opportunities, and the balance of authority between Directors and their respective Services. The Task Force neither conducted a detailed evaluation of the scientific and technological output of the Labs nor conducted a “right sizing” exercise for the Labs.

1. Introduction

1.1 Key Messages

In the era of technology globalization, the DoD laboratories and engineering and warfare centers (“the Labs”) continue to fulfill vital missions on behalf of the warfighter. The Labs’ traditional missions are defined as *“high quality science, technology transition, and smart acquisition.”* While these missions remain important and relevant, the rapidly changing technology and threat landscapes dictate the Labs should also adapt their missions to continue serving the warfighter; this includes an expanded set of missions to focus on technology leadership, open innovation, and technology defense. The Labs are substantial enterprises housing over 40,000 scientists and engineers. They are big organizations and should adapt and transform in order to deliver on these new missions. Specifically, the Labs should ready themselves for their evolving missions by adapting operating models, culture, workforce, infrastructure, and the way in which they collaborate. This is not a trivial exercise due to the magnitude of the change and because the Labs exist in the broader defense system, which is not optimized for their operations. Congress has traditionally been a strong advocate and supporter for the Labs. Congress should continue working with the DoD to simplify the regulatory environment in which the Labs operate to give them the tools they need to succeed in this new environment.

1.2 The Value Proposition of the Labs: A Proud Heritage of Defense Science and Technology

Much has been written about the commercialization of technology innovation outside the perimeter of the defense research enterprise. While it is true that innovation centers such as Silicon Valley operate outside the direct influence of national security considerations, it is also true the DoD and its Labs continue to produce important science that influences the commercial sector as much as the DoD is influenced by commercial technology. A notable example of this is the Oculus Rift technology, which became pivotal in the renaissance of the Virtual Reality field after

its acquisition by Facebook. The Oculus Rift directly benefited from work funded by the Army Research Lab (ARL) through the Institute for Creative Technologies (ICT) at the University of Southern California (USC). This is perhaps an evident example of DoD Lab-sponsored technology influence. However, the Department and its mission also influence the discourse in the scientific community in more subtle but no less influential ways. The miracles of modernity, digital computers, jet aircraft, cell phones, the Internet, lasers, satellites, global positioning system (GPS), digital imagery, and nuclear and solar power emerged from focusing scientific creativity to the

Oculus Rift: A Story of the Labs Leading Industry

Lab research led directly to one of the biggest technology vectors in Silicon Valley: virtual reality headsets, researched by the ICT— an Army-sponsored, USC-affiliated research center managed by the ARL. The technology was originally intended for creating immersive training environments for culture aware missions and is now utilized widely by the industry. The ICT developed open-source hardware and software, used off-the shelf components, and leveraged industry collaborations. This “disruptive model” influenced industry by releasing open source designs and lowering the price.

technological needs of the Department.

1.3 The Labs and Centers are Essential to the Warfighter

The Labs play an essential role in the DoD technology pipeline. The Task Force believes that if the Labs did not exist today they would need to be invented. The Labs operate in an intricate technology supply chain and associated ecosystem, bridging the gap between speculative research and development (R&D) and fieldable technology at scale. They are essentially the technology “muscle” of the DoD. Without the expertise, R&D, and engineering capacity of the Labs, the DoD would not only lose a key asset that tailors technology to its needs, but it would also lose the competency that enables sourcing technology from the vendor community.

The Task Force understands that not all Labs are the same. The “corporate” Labs (e.g., the ARL, the Navy Research Laboratory (NRL), the Air Force Research Laboratory (AFRL), and the Engineer Research and Development Center (ERDC)) focus on both discovering and transitioning technology to the warfighter. The Centers further down the pipeline transform technology into fieldable systems and deliver it into the hands of the warfighter. The value proposition of the Labs and Centers is an enduring one. They are critical DoD assets that discover and transition science and technology (S&T) to ensure the United States remains dominant in land, air, sea, space, cyber, and domains beyond in military capabilities. The Labs provide sustainable, disruptive advantage to U.S. forces by developing leap-ahead S&T and rendering current weapon systems more effective and affordable by enabling the Department to be a smart buyer.

1.4 Task Force Observations

The Task Force found opportunities for the Labs to enhance their contributions to the Department:

- » To maintain and enhance their value proposition, the Labs need to embrace open innovation and technology defense – security need not equal isolation.
- » The Labs need to be more active (and “at the table”) in the DoD requirements process. It is incumbent upon the Labs to not only provide what the Department or the Services ask for, but also help the Department formulate requirements by injecting the technology perspective into the requirements definition process.
- » The Labs need to lead the DoD through fundamental technology shifts by being able to anticipate and canvass emerging and future requirements and evolving missions. There are acute challenges in many areas including software development and acquisition, autonomy, and cybersecurity, to name but a few. The Labs need to step up and take ownership of these big issues and guide the Department through the thicket.
- » The DoD (Office of the Secretary of Defense (OSD), the Services, and the Combatant Commands) needs to actively engage in the evolution of the lab enterprise to ensure its readiness for the challenges of a rapidly changing technology and threat environment. The Labs operate in an environment that is not optimized for their missions. They need support

from the DoD to make the adjustments required in order for them to adopt state of the art operations practices alongside carrying out state of the art R&D.

- » Congress has been a great supporter of the Labs and has provided crucial advocacy as well as legislation to strengthen the operational excellence of the Labs. The Task Force believes Congress needs to continue working with the DoD to simplify the regulatory environment the Labs operate; yet, the Labs need a culture shift to utilize the authorities already granted, and they should be better aware of the tools available and willing to use these tools and authorities in support of and improvement to their missions.
- » The Task Force found opportunities for enhanced collaboration between the Labs and the Centers. For example, improvement is needed to create a well-defined and managed technology pipeline, starting from basic research in the Labs and ending with the deployed system via the Centers. Expanded coordination among intramural basic research portfolios across the Labs without creating additional administrative burdens is needed. The defense research enterprise should collectively look for opportunities to identify facilities and equipment to be co-invested in and shared by the Labs.

2. The Current and Evolving Mission of the Labs

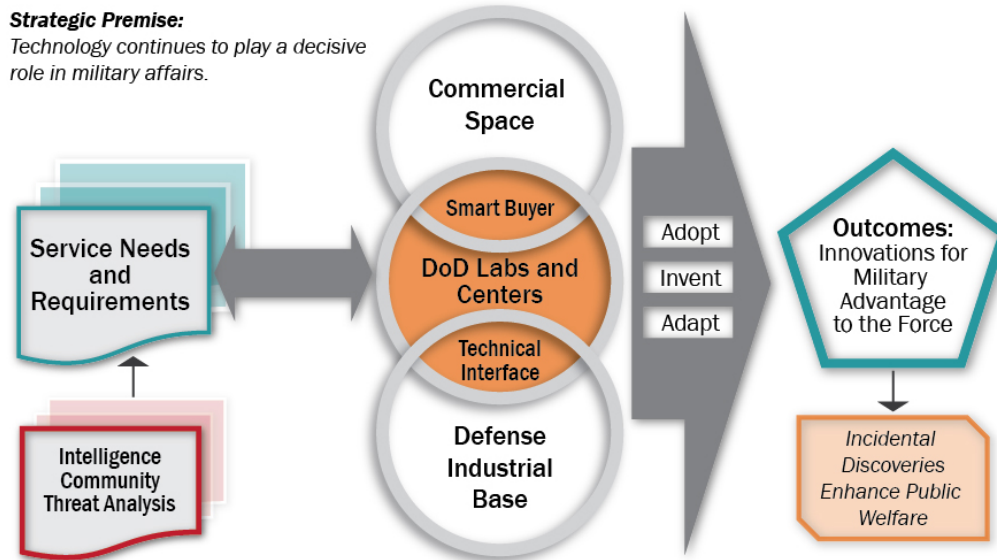


Figure 1. Lab Mission

2.1 Existing Lab Missions

The Labs and the Centers have historically been responsible for:

» **Conducting great basic science**

- Focus on and anticipate warfighter needs in the future and work on problems that will not be solved by the technology community outside the defense enterprise.

» **Supporting technology transition**

- *Prototyping*: Prototype to facilitate transition of new and innovative technology to the warfighter.
- *Mission-driven S&T*: Focus S&T investments in areas directly supporting warfighter needs and maintain an understanding of operational deficiencies.
- *Engineering*: Develop and promulgate essential engineering practices for the Department, including those needed for the efficient and timely production of software.
- *Timeliness*: Transition technology to the warfighter faster than our adversaries.



Figure 2. Existing Lab Roles

» **Facilitating acquisition of technology by the DoD (“smart buyer”)**

- Support acquisition programs by injecting specialist technology know-how at all stages of the process.
- Identify and support the acquisition of commercial technology whenever it meets mission requirements.

Example of Great Basic Science: NRL’s Permanent Magnet

- » In 1980, NRL scientists N.C. Koon and B.N. Das were the first to examine the magnetic properties of rare earth-iron-boron (R2-Fe14-B) alloys, which showed promise for permanent magnet use.
- » NRL scientists conducted the first work on these materials and hold the fundamental U.S. patents. These NRL patents have been licensed to several firms, and products are being offered commercially.
- » Since 1983, commercial alloys based on R2-Fe14-B have been in commercial production. By 1985, these materials provided almost twice the magnetic energy density of the best materials previously available.
- » These magnetic materials are eventually expected to cost much less than older materials because they are made from less expensive and more abundant elements.
- » They also offer relatively good corrosion resistance and are easily formed into complex shapes.
- » These materials promise to be useful in both the military and the commercial sectors for improved microwave tubes, sensors, powerful lightweight electric motors and generators, computer peripherals, and faster, more compact actuators.

Example of Smart Buyer: AFRL-BATMAN

- » AFRL Battlefield Air Targeting Man-Aided Knowledge (BATMAN) program managers developed the Key Performance Parameters (KPP) called out in a Source Requirement Document (SRD) fulfilling a gap identified in a Capability Development Document (CDD) and deliver it in accordance to a schedule set forth in a Technology Transition Plan (TTP) between AFRL/BATMAN and Air Force Life Cycle Management Center (AFLCMC/WISN).
- » Tech development is more often contracted out, thereby establishing a vendor that could respond to a request for proposal (RFP) from the Program Office to supply the needed capability
- » Air Force Special Operations Command (AFSOC) documented a need to enhance hearing protection and improve localization for the tactical headset. BATMAN worked with AFLCMC to plan out a technical schedule aligning to Program Objective Memorandum (POM) funding for the headset. BATMAN contracted out two efforts with defense contractors: SPEAR Labs and Silynx - known experts in the field of tactical headset development with several products already on the market.
- » BATMAN matured and elevated the state-of-the-art for tactical headsets incorporating requirements for AFSOC and tested to the Program Offices SRD. Within the scheduled timeframe, agreed in the signed TTP, BATMAN transitioned to the Program Office’s two competitive options. The Program Office released an RFP and source selected a new headset meeting AFSOC requirements.
- » A by-product of BATMAN’s efforts engaging with defense contractors to improve the current state of a technology is that the Government raises the bar for other vendors attempting to compete and respond to the Program Offices RFP.

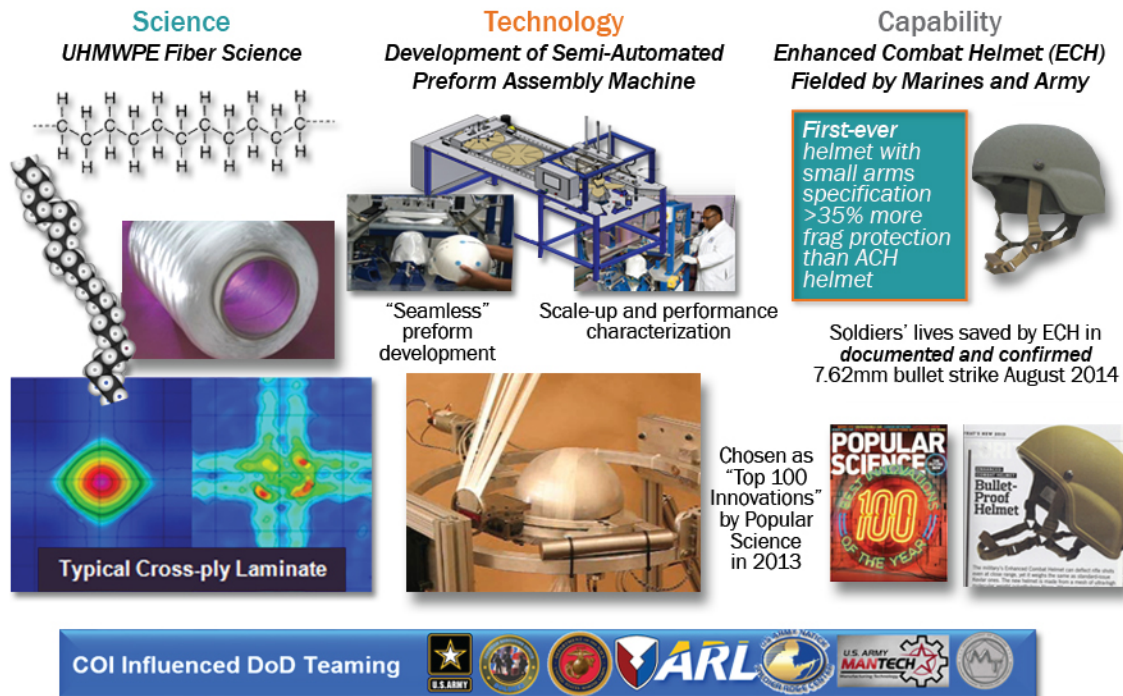


Figure 3. Example of Tech Transition: ARL Enhanced Combat Helmet (ECH)

As seen in **Figure 3**, the ARL led a joint Army-industry team to develop new processing methods that enabled the development and fielding of the Enhanced Combat Helmet (ECH), an ultrahigh molecular weight polyethylene (UHMWPE) composite helmet that is replacing the Kevlar composite Advanced Combat Helmet (ACH). The ARL created innovative composite architectures for the ECH to maximize its performance. The combination of improved materials, processing, and design resulted in a lighter helmet that provides better protection. The Army-industry team that developed the ECH was recognized as part of the "Top 100 Innovations" by *Popular Science* magazine in 2013.

2.2 A few examples of other key contributions:

- » **AEGIS Combat System—Gold Standard for Navy's Combat Control and Weapon System Engagement**
 - The NRL's fundamental contribution to the AEGIS combat system was the underlying radar technology. Building on decades of work in radio-wave propagation theory and the development of the first radars deployed in the Navy, the NRL refined and expanded the capabilities of radar technologies. Major achievements in this area include: over-the-horizon radar, high-resolution radar, inverse synthetic aperture radar, and low observables detection radar. These innovations contributed significantly to the Navy's situational awareness capabilities and to the development of countermeasures. The same capabilities have also been applied in systems of the other Services and in civilian radar systems.

- A further critical technology developed by the NRL and transitioned into the AEGIS Weapon System is Human Alerting and Interruption Logistics (HAIL), an alert and interruption mediation system. A naval warfighter's ability is increased 25 to 85 percent to perform more effectively during high rates of alert-based interruptions. During the Gulf War, alerting-based cognitive overload was one of the most serious operational problems for AEGIS. Recognizing the problem, the NRL conducted the basic and applied research for HAIL from 1995 to 2000 and transitioned it to industry to further develop and mature the technology. As the builder of the AEGIS weapon system, Lockheed Martin Maritime Systems and Sensors started production of HAIL-Surface Ship in 2004 and led its transition into the Fleet under the direction of the AEGIS Program office.

» **Navy's Laser Weapon System—The World's First Fielded Shipboard Laser**

- Asymmetric warfare is placing new demands on the Navy. Fast small targets such as unmanned underwater vehicles (UUVs), unmanned aerial vehicles (UAVs), improvised explosive device (IED)-laden piloted vessels, and supersonic missiles demand weapons with a low cost per shot, deep magazine, high precision, high speed, and compact enough to use on the Navy's smaller craft. In 2005, NRL scientists were the first to propose and simulate the use of incoherently combined, high-power fiber lasers as the architecture for the Navy's first fielded shipboard laser, the Laser Weapon System (LaWS).
- Shortly after the initial analysis and simulation of the concept, NRL scientists and team members from the Naval Surface Warfare Center Dahlgren Division (NSWCDD) carried out the first long-range field experiments. The NRL team repeated experiments at the Starfire Optical Range at Kirtland Air Force Base (AFB) at a range of 3.2 kilometers. In the summer of 2014, LaWS was deployed in the Persian Gulf aboard the USS Ponce. It downed a UAV in testing and destroyed moving targets at sea at less than one dollar a shot; a conventional projectile can cost up to \$20,000. Only months later, LaWS was declared an operational asset and the ship's commander was given permission to defend the ship with the weapon.
- Such solid-state fiber laser (SSFL) systems promise easy shipboard integration and are compact enough to be installed on ships as small as the littoral combat ship (LCS) class. SSFLs are relatively low-maintenance, have a low operating cost, and high wall plug efficiency makes less of an impact on the ship's power supply. SSFLs such as the LaWS can also disable or jam electro-optical sensors, counter electrical optical (EO)-guided missiles, and detonate rocket-propelled grenades. These lasers are easier to cool, provide good beam quality, and can achieve up to 35 percent level of efficiency relative to the power provided to the system - a higher than average rate compared to other lasers.

» **Electromagnetic Railgun—R&D on a Revolutionary Prototype**

- The NRL's railgun program began in 2003 and has since become a critical element in the efforts to develop hypervelocity electronic weapons for long-range fire support and ship

defense. The current model railgun can send a kinetic energy warhead at speeds up to Mach 6 toward targets as distant as 110 nautical miles. Researchers estimate electromagnetic launchers could one day reach ranges of 200 nautical miles. When the Navy deploys its first hypervelocity electric launcher, its success will be partially due to the NRL's work.

- At the time of writing, researchers from three NRL divisions (Materials Science and Technology, Plasma Physics, and Chemistry) are working on an Innovative Naval Prototype project to construct, test, and facilitate acquisition of the Navy's first generation of railgun. For this project, researchers set up the NRL Materials Testing Facility, featuring an 11 megajoule, six-meter barrel railgun designed for diagnostic access and experimental flexibility. Railguns have substantial power demands needing to be pulsed and cycled (or released and recharged) several times a minute. Thus, research challenges included the need for compact pulsed power, energy storage, development of a high-speed low-drag projectile, and an effective thermal management system. Researchers are concentrating on demonstrating a repetitive-fire rate capability and thermal system management techniques for both the launcher system and the pulsed power system to withstand sustained firing. Researchers are also testing for railgun wear and damage over time, which could have catastrophic consequences for a ship and crew.
- When fielded, this weapon system has the potential to provide ships with revolutionary long-range multi-mission capabilities for ballistic and cruise missile defense, long-range land attack, and anti-surface warfare. Because the projectile is launched by electromagnetic pulse, it spares Navy ships the risk of handling and storing conventional gun propellants. In 2015, the Chief of Naval Operations (CNO) praised the potential cost savings, contrasting a railgun projectile, which costs about \$25,000 per shot, with a cruise missile of comparable range, which costs around \$1 million.

» **Automatic Ground Collision Avoidance System—Already Saving Lives**

- The Automatic Ground Collision Avoidance System (Auto GCAS) is designed to prevent controlled flight into terrain mishaps due to target fixation, task saturation, spatial disorientation, and G-force Induced Loss of Consciousness (GLOC). The Auto GCAS is an onboard system that projects a future aircraft trajectory over digital terrain elevation data loaded on the aircraft prior to takeoff. If the trajectory intersects the digital terrain, the Auto GCAS requests a roll to wings level 5G fly up from the flight control computer. The flight control computer then automatically commands a fly up. Control is given back to the pilot as soon as the aircraft's flight path clears the terrain. The Auto GCAS operates in the background without affecting the pilot's performance or interfering with the mission of the aircraft. The Auto GCAS for aircraft with digital flight control computers was integrated on the Air Force's block 40/50 F-16s in the fall of 2014 and, at the time of this report, has saved the lives of four pilots and their aircraft. The Line-in-the Sky (LIS) variant of the Auto GCAS was fielded in the F-22. Auto GCAS is also planned to be fielded on the F-35 in Block 4. The AFRL is in the process of developing a solution for integrating the Auto

GCAS on the pre-block 40 F-16s using its analog flight control system.

- The AFRL initiated the development of the Auto GCAS back in the late 80s and over the past 20 plus years has managed the development and transition of this life saving technology to Air Force fighter aircraft.

» **The First Operational U.S. Sonar—Transformed Surface and Undersea Warfare**

- The Navy started underwater acoustic research in 1917 with a small group at the Naval Experimental Station in New London, Connecticut, to investigate the use of underwater sound during World War I. This group was transferred to the NRL when it began operations in 1923. The NRL researchers believed that the passive sonic devices used in World War I were seriously limited in the detection of enemy submarines. It was their belief that active echo-ranging sonar would provide the best antisubmarine warfare system for surface ships. This approach was taken from the start of the Sound Division at the NRL, where practically the Navy's entire R&D in sonar prior to World War II was carried out.
- The NRL's first effort was to develop an improved quartz-steel transducer. Extensive effort was placed on each of the components of the new sonar system, from the transducers and signal processing to the mechanical mounting and housing functions. Particularly significant was the development of the streamlined sonar dome to house the transducer. The dome enabled surface ships to make attacks at speeds up to 15 knots. In 1927, a number of naval vessels conducted tests with the NRL quartz-steel echo-ranging sonar. This was the first practical sonar based on the 1918 demonstration by Paul Langevin, a French physicist, of the possibility of echo-ranging or "pinging" at supersonic frequencies.
- A later system, called the Echo Detection Equipment Model QB, became the first operating sonar used by the Navy. Sonar transformed naval warfare by improving the ability of surface ships and submarines to detect and track enemy submarines.

» **XAF—The First U.S. Radar**

- Prior to the development of radar, Navy ships could track other ships or aircraft only by using optical techniques, sound ranging, or primitive radio direction finding. New methods of detection and ranging were necessary. In 1922, while working on radio direction finders for aircraft, Albert H. Taylor and Leo C. Young noted a distortion of "phase shift" in radio signals reflected from a steamer on the Potomac River. In short, the NRL had detected a moving ship by radio waves and had, as a result, discovered the radar principle. Eight years after the initial discovery of the radar principle, NRL scientists observed that reflections of radio waves from an airplane could also be detected.
- From 1930 to 1940, the NRL explored the use of radio for detection and ranging. In 1933, the use of a pulse technique to detect aircraft and ships was proposed by Young. R.M.

- Page made major advances over the next few years in the area of transmitters and receivers, eventually developing the highly important “duplexer” in 1936. The duplexer permitted the use of the same antenna for both transmitting and receiving. The pulse technique combined with the duplexer did away with the separate receiving and transmitting antennas most of the other early radar developers employed. Page and Young received the patents for the duplexer, an invention that dramatically changed the nature of radar in the United States and abroad.
- The NRL invented, developed, and installed the first operational U.S. radar, the XAF, on the battleship USS New York in 1939 which was rapidly transferred to industry for production. By the time of the attack on Pearl Harbor, 20 radar units were in operation. Radar of this type contributed to the victories of the Coral Sea, Midway, and Guadalcanal. Among the lessons learned at Coral Sea was that every carrier should be equipped with two long-range radars, according to the Commander in Chief of the Pacific Fleet (CINCPAC) Admiral Chester Nimitz.
 - The invention of radar and the developments that flowed from it (e.g., monopulse radar and over-the-horizon radar) are among the foundations of modern military power. Moreover, as a sensor for navigation and surveillance, radar plays a major role in the operation of civilian transportation systems, weather forecasting, astronomy, and automation among other uses.

» **Galactic Radiation and Background I—The First U.S. Operational Intelligence Satellite**

- The now unclassified Galactic Radiation and Background I (GRAB I) payload, a co-flyer with the publicly recognized Solar Radiation I (SOLRAD I) scientific payload, was the United States’ first operational intelligence satellite. In June 1960, 52 days after a U-2 aircraft was lost on a reconnaissance mission over Soviet territory, the GRAB I satellite soared into orbit and began transponding space-intercepted electronic intelligence signals to Earth-bound signals intelligence stations. The notion of operating the antenna/detector reconnaissance technology in an orbiting satellite and collecting its transponded signal on magnetic tape was a breakthrough answer to CNO Admiral Arleigh Burke’s request for naval material bureaus and laboratories to consider how they could use space in their design ideas for the Navy.
- With mission sponsorship by the Office of Naval Intelligence, the NRL completed development of the satellite and its network of overseas ground collection sites. President Dwight Eisenhower approved the electronic intelligence (ELINT) program and its SOLRAD I scientific experiment cover. The GRAB I/SOLRAD I payloads shared a ride into space with the Navy’s third Transit navigation satellite as part of the world’s first multiple satellite launching.
- The GRAB I project created a proof-of-concept for satellite-collected ELINT. This was accomplished by demonstrating that a platform in outer space could collect as much as all other sea, air, and land-based reconnaissance platforms operating within the satellite’s field of view at a fraction of the cost and at no risk to personnel. The intelligence

information gained from GRAB I had profound impact on national security decision making and on deterrence of nuclear war with the Soviet Union.

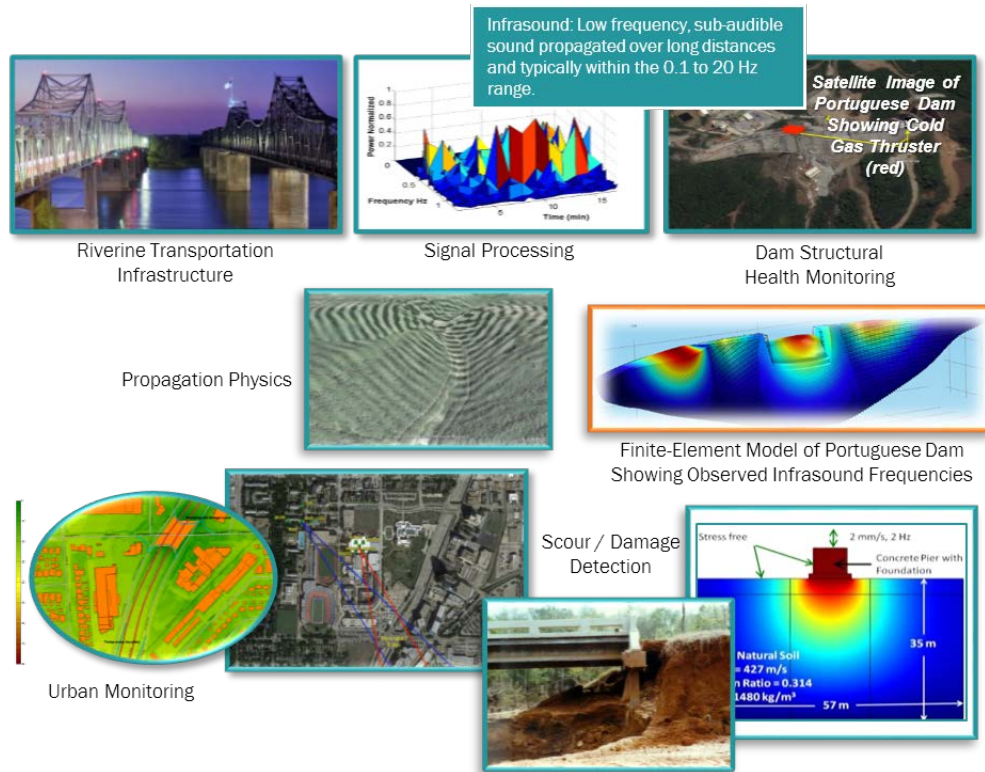


Figure 4. Supporting the Warfighter: ARL Remote Assessment of Critical Infrastructure

Researchers at the ARL’s ERDC have been experimenting with Infrasound or low frequency sound (less than 20 Hz), shown in **Figure 4**. Infrasound has the inherent ability to traverse long distances with little loss. The researchers at the ERDC were able to discover that by exciting various structures and listening for the intrinsic harmonics associated with the structures, they could ascribe a characteristic signature to different structures and use change detection to determine if there was any damage associated with the structures. They can literally hear the structure’s “song.”

These achievements speak loudly of the proud heritage of technological breakthroughs and critical advantages that the Labs have created and conferred to the Warfighter since their inception.

2.3 Findings

Delivering on Existing Missions

While the DoD’s in-house research and engineering enterprise conducts S&T in response to the DoD’s needs, the Task Force found the absence of an overall DoD S&T plan makes it difficult for the Labs to prioritize and plan their own work. This notwithstanding, the Task Force concluded that the S&T portfolios, planning and timelines at the Labs and the Centers can be better aligned

with DoD acquisition and emerging missions. There seems to be a lack of focus and sense of urgency on critical emerging technology area needs especially in the information technology domain (IT), including software, systems engineering, complex systems, autonomy, big data, and cyber engineering and operations. There is a clear need here for the Labs and the Centers to inform their strategic direction from the DoD priorities in addition to their own bottom-up efforts and, in turn, they should strive to inform DoD technology priorities.

The Task Force found a disconnect between the Labs and the acquisition process in terms of timing. The relatively high degree of autonomy the Labs enjoy with respect to their S&T portfolio has the downside of their work often being out of synch with the S&T needs to support a specific requirement. The Labs are often “too early” with some technological advance, or “too late” because industry has a better insight into DoD/Service needs. This problem is likely to be exacerbated given the growing dependence of the DoD on commercial off-the-shelf (COTS) derived technologies to meet requirements for advance capabilities. In this regard, the Labs behave more like arsenals (e.g., nuclear weapon labs, Watervliet Arsenal), working exclusively on their niche areas of expertise unless tasked to do otherwise. While the Task Force argues that the Labs should have a “seat at the requirements table,” we also recognize that the Labs need to put themselves in a position to meet the need.

The Mission of the Labs is Evolving

Underlying everything the Labs do is the imperative to avoid technical surprise to the detriment of the DoD mission. The Labs should leverage their connections to the global scientific and technology community to maintain awareness of upcoming disruptive technologies and partner with the Intelligence Community to counter known and developing adversarial technological advancements. The Labs also need to be aware and present in the key technology hubs in the United States and abroad. They need to build and maintain relationships with the global technology community in order to harvest globally developed technologies for the Department while minimizing the exposure of U.S.-developed critical technologies.

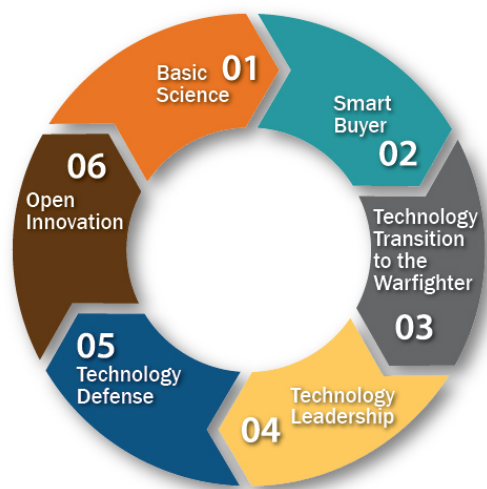


Figure 5. Evolving Lab Missions

The Labs must cope with accelerating globalization and a rapidly changing technology landscape with more innovation happening outside the defense S&T perimeter rather than inside. The Labs should therefore rapidly adapt and evolve their missions to continue to support the Department in this environment. The Labs and the Centers should help the Department navigate large technology shifts and prepare it to develop and acquire technology in this changed environment. As noted earlier, the Labs also should work to protect U.S. technologies as they take advantage of the technology developed by others. A key strategy for the Labs should be to support the

Department by embracing open innovation by building bridges with non-traditional defense S&T vendors. The Task Force found that in order to continue being responsive to DoD needs, the Labs should evolve their missions to include:

- » **Technology Leadership**—lead the Department through massive technology shifts, such as autonomy and the inexorable rise of software.
- » **Technology Defense**—protect our technology advantage.
- » **Open Innovation**—embrace technologies developed outside the Department and integrate it into defense systems by building links with the broader innovation community and tapping into it on behalf of the Department.

Technology Leadership

The Labs and the Centers contain the bulk of technology and engineering expertise of the Department, almost 40,000 scientists and engineers. This is the core muscle the Department has to create, transition, and deploy technology to the warfighter. The Labs deliver on their mission today by building and maintaining expertise in key areas, which in many cases reflects the history of the Labs themselves alongside current thinking for warfighter needs. These historical portfolios, however, can also create blind spots and gaps. The Task Force found R&D programs in certain areas such as software are not as current as they should be. For example understanding and adapting the use of agile software development methods to Department acquisitions. This is a multi-faceted challenge for the Labs. First, the Labs' R&D investments are not as effective as they need to be. Second, by not being current with software development and validation methods, multiple programs in their own portfolios are slowed down. Third, and perhaps most importantly, the Labs are not able to help the DoD scale these same challenges. In areas such as software and autonomy, it is not enough for the Labs to follow the trends; they need to lead them and do so on behalf of the Department.

Software, autonomy, and cyber are today's core challenges. More broadly and looking forward to the challenges of tomorrow, the Labs should anticipate technology shifts, align them with emerging threats, and develop key capabilities. Thus, the Labs should put themselves in a leadership position to inform the DoD's technology strategy and influence technology investments and priorities.

Technology Defense

As R&D enterprises, it is essential for the Labs and the Centers to be a part of the scientific and research communities, both at home and globally. It is equally essential for them to understand their special place in these communities. The primary mission of the DoD in-house research and engineering establishment is to deliver military advantage to the force, through science and technology. This can be accomplished in several ways: invent, inform technology acquisition, and advise the Defense Industrial Base (DIB) and commercial vendors.

At the same time, the Labs and the Centers should think defensively. A corollary to the primary mission is to ensure the technological edge they supply is sustainable against a smart and evolving

adversary. The Labs and the Centers should ensure critical technology details are not available to adversaries who might then be able to counter our capabilities, and/or acquire those same capabilities. A robust security and counterintelligence regime should be followed.

A second corollary is to recognize incipient vulnerabilities in the technologies; every capability is a vulnerability, and excess capabilities are unnecessary vulnerabilities. The Labs and the Centers should sufficiently inform the needs, requirements, and acquisition processes so proper cost-benefit calculations can be made. A strong red team presence should support a “smart buyer” approach.

A third mission corollary is to ensure that, should the technology be acquired by an adversary or “escape into the wild,” the consequence can be mitigated. Serious efforts should be made to safeguard the technology.

A fourth mission corollary is sustainment of the technology time advantage over our adversaries. This is even truer today where the speed of technology adoption by our adversaries is only matched by the pace of change in technology itself. The Labs should strive to incorporate innovation in defense systems as expeditiously as possible. The system needs to aim at speed.

Open Innovation

Silicon Valley is teeming with company outposts from all over the world. Consumer electronics giants, silicon manufacturers, aircraft manufacturers, and automakers, to name a few, are all there. Alongside sales offices and R&D centers, Open Innovation Centers abound. Their purpose: to gain visibility into talent and technologies they can acquire to further their interests. Open innovation is about building a presence in and bridges with innovation hubs such as Silicon Valley, the Boston Corridor, and others. The Labs are mostly absent from these hotspots and the cost to their mission in support of the warfighter is very real. While efforts, like the Defense Innovation Unit Experimental (DIUx), are building links with non-traditional defense vendors, the absence of the Labs from these innovation hotspots means they are not able to act as the eyes and ears of the DoD when it comes to technologies and talent in these areas. The Task Force believes that the Labs should establish a robust presence in each such innovation hub including locating researchers and engineers locally so they can take advantage of the technology transition opportunities as well as the local talent pool.

The ARL Open Campus is a commendable example of open innovation that can serve as a role model to the broader defense research enterprise. Open Campus is a collaborative endeavor, with the goal of building an S&T ecosystem to encourage groundbreaking advances in basic and applied research areas of relevance to the Army. Through the Open Campus framework, ARL scientists and engineers (S&Es) work collaboratively and side-by-side with visiting scientists in the ARL's facilities and as visiting researchers at collaborators' institutions. Central to the research collaborations is mutual scientific interest and investment by all partners. The global academic community, industry, small businesses, and other Government laboratories benefit from this engagement through collaboration with the ARL's specialized research staff and unique technical

facilities. The collaborations build research networks, explore complex and singular problems and enable self-forming, expertise-driven team building. These collaborative efforts are well-positioned for competitive research opportunities and expose S&Es, including professors and students, to realistic research applications and perspectives. In the end, the ARL Open Campus concept helps to ensure the Nation's future strength and competitiveness.

The Task Force wishes to note that there was nothing inevitable or easy in creating and realizing the Open Campus model. It runs counter to the established notions of building a wall between the DoD scientific community and their peers on the outside. The vision and determination of the ARL leadership to bring the collaboration advantage to the warfighter found a way to cut a path through the complexity of operating in the defense research enterprise. An early example of Open Campus Extreme Batteries collaboration illustrates the benefits.

Open Campus Example: Center for Research in Extreme Batteries

The non-profit consortium Center for Research in Extreme Batteries (CREB) was established in October 2016 to be funded by industry, academic, and Government partners, with over 100 potential collaborators. Four funded postdoctoral fellows, including two international researchers, are pursuing battery S&T with a focus on extreme environment performance.



Technical Accomplishments:

- » “Water-in-salt” electrolytes dramatically increase electrochemical stability to 3 V over previous state of the art (1.23 V)
- » Breakthrough 100 Wh/kg energy density demonstrated (a 43 percent increase over current Li-ion technology)
- » Non-flammable/non-toxic electrolytes
- » Joint ARL/UMD patent filed
- » High impact publications in *Science Magazine* and *Angewandte Chemie*

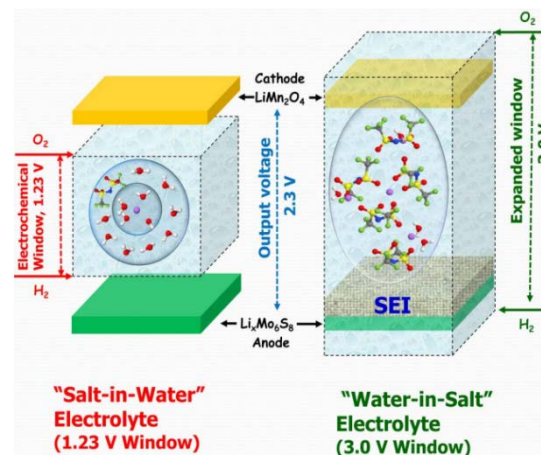


Figure 6. Battery Chemistry Research

2.4 Recommendations Regarding the Existing and Evolving Lab Mission

- » The Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) should, as a matter of priority, produce a national security S&T strategy that will inform lab investment in critical DoD mission areas and help frame investment priorities.
- » The Lab Directors should create and maintain technology leadership, technology defense, and open innovation plans.
- » The ASD(R&E) should produce a plan to create a robust joint Lab presence in innovation hubs around the country and should coordinate its establishment by leveraging the ARL Open Campus exemplar.

3. Lab Operating Models

3.1 Working Capital Fund and Mission Funding

The Service's laboratories, engineering centers, and warfare centers range in size, location, mission, and operating model. The Army, the Navy, and the Air Force each have a corporate laboratory, and the Army and Navy have engineering and warfare centers, respectively. While collectively referred to as "the Labs," these organizations differ substantially in many respects:

- » they can be mission funded, working capital funded, or a combination of mission and customer reimbursable funded;
- » they employ differing levels of civilian, military, and contractor personnel; and
- » their work ranges across the spectrum from basic research to maintaining fielded systems, including system lifecycle extension.

So the Lab portfolios are a mix of basic research, applied research, and technology transition. It follows then that the way the Labs are funded should also reflect this mix. While annual budgeting of short- and mid-term R&D is possible, longer term research requires a longer planning cycle. Applying the Working Capital Fund (WCF) model across the entire lab portfolio, for example, is not consistent with multi-year scientific processes, which require stability and long-term planning.

1. Working Capital Fund (WCF)

- ▶ Nearly all costs are recovered via labor rate charges billed to customers
- ▶ Laboratory directors have the responsibility to sell capabilities to resource sponsors and deliver products
 - Necessitates entrepreneurial activities; customer oriented encourages agility
 - A successful WCF lab will have a net operating result (NOR) of \$0 on 30 September of each FY

2. Mission Funding

- ▶ All funds are appropriated by headquarters
- ▶ Lab directors manage rigorous budgets and requirements established by their Service
- ▶ Strict mission focus



Figure 7. DoD Operating Models

3.2 Comparison with Overseas Partner Labs, Federally Funded Research and Development Centers, Government-Owned, Contractor-Operated Facilities, and Private Labs

	DoD Labs & Centers	Overseas Partner Labs	FFRDCs, UARCs, & GOCOs	Private Labs
Budget Authorization	Annual	Annual review	Annual	Annual
Budget Planning	5 years	5-10 years	5 years	Annual
Lab-level Authority to Hire	Mixed	Corporate level planning	Yes	Corporate level planning
Flexibility of Compensation	Government defined	Government defined	Competitive with private sector	Competitive
Infrastructure Planning and Maintenance	Tied to Service infrastructure budget	Self-directed	Sponsor funded	Corporate level planning
Budget: Competed vs. Base Funding vs. Work for Others (WFO)	Mixed	Base funding	Base & WFO	Market-based

The Task Force considered the Labs' operating models in comparison with those of Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), government-owned, contractor-operated (GOCO) facilities, and overseas partner labs as well as private ones. We consistently found that the Labs operate under significantly more restrictive environments than their peer labs in the Department of Energy (DOE), overseas and private industry, including the ability to plan their portfolio, manage to their budget, hire, and compensate their people and maintain and renew their infrastructure. While the contrast is perhaps starker in the case of private labs, it is noteworthy that overseas peer labs have significantly more control over their local affairs and operate with levels of autonomy quite rare in the case of the DoD Labs. It is also the case the overseas partner labs operate in a significantly smaller and simpler context, in most cases reporting directly to the Department they support versus the Services. Collectively, these factors allow the overseas partner labs to manage their own affairs, including making tradeoffs and investment decisions with significant autonomy and stability. While the Labs operate in a significantly larger and more complex defense enterprise, it is nonetheless incumbent upon both the OSD and the Service Secretaries to strive to devolve as much authority and responsibility locally to the Labs so they can manage their own affairs to deliver on their missions.

3.3 Lab Operating Model Recommendations

- » To function effectively, the Labs need a mix of core mission funding and work for others. The Secretary of the Navy (SECNAV) should ensure the Navy labs and centers have a base mission fund.
- » The Lab Directors should align and manage their portfolios in line with the DoD S&T strategy developed by the ASD(R&E) as well as their home Service priorities.

4. Lab Readiness: A Spirited Culture of Self-Reliance

4.1 Findings

Lab Culture

The Task Force defines *culture* as the set of pervasive values, beliefs, and attitudes that characterize a Lab and guide its practices. The Task Force visited five labs and sampled their cultures. In each case, it was striking how closely the lab culture reflected the leadership style of the Director and that of the Service leadership itself. The Task Force observed both ends of the spectrum: Labs that refuse to take no for an answer and labs that have surrendered to the bureaucracy. The Task Force believes the Labs serve the DoD and their people best when they assume responsibility for their own affairs and work within the system to find ways to better fulfill their mission. The ARL Open Campus initiative exemplifies this positive culture.

Authorities Granted but Not Exercised

Culture is material to the mission of the Labs. The Task Force found that many authorities have been granted to the Labs to help ease their operational constraints, but these authorities are not being exercised because of misperception, internal constraints, or cultural inhibition. Collectively, the reluctance or inability to exercise these important authorities materially affects the ability of the Labs to manage their own affairs. Examples of authorities granted, but not or not fully exercised include:

- » **Fiscal Year (FY) 2009 National Defense Authorization Act (NDAA) Section 219**—Mechanisms to Provide Funds to Defense Laboratories for R&D of Technology for Military Missions:
 - Not all Labs utilize this authority up to the full three percent of research, development, test, and evaluation (RDTE) funding as authorized by Congress. Lab Directors are faced with many challenges in re-programming money due to their Service headquarters oversight.
- » **FY14 NDAA Section 1107(h)**—Exclusion from Personnel Limitations, a.k.a. “Manage to Budget” Authority:
 - The Services can place their own caps on personnel numbers due to pressures to keep overall staffing numbers down; this limits the Labs ability to utilize this authority.
- » **FY15 NDAA Section 1105**—Student Direct Hire Authority:
 - The Labs and the Under Secretary for Personnel and Readiness (USD(P&R)) have different opinions on legal interpretations surrounding the use of a Federal Register Notice to utilize the authority.
- » **FY16 NDAA Section 1109**—Voluntary Early Retirement/Voluntary Separation Incentive Payments (VERA/VSIP), Flexible Term Appointments, and Voluntary Emeritus Corps:
 - Similar to Student Direct Hire Authority, the Labs and the USD(P&R) have different opinions on legal interpretations surrounding the use of a Federal Register Notice to utilize this authority.

- » **FY16 NDAA Section 2803**—Defense Laboratory Modernization Pilot Program (\$150 million authorized RDT&E funds for major projects):
 - The Services and the Labs have noted there have not been funds appropriated specifically for execution of this pilot. The Services have been wary of re-programming funding away from what Congress initially intended because of the long-term impacts of decrementing or diverting their scarce S&T funding for other purposes such as infrastructure maintenance and repair.

Local Control for Local Matters

Lab control over local matters varies among the Services. The Navy places particularly onerous restrictions on Lab and Center operations. For example, while the Army and the Air Force have largely devolved conference approval to Lab Directors, the Secretary of the Navy requires

Examples of Dysfunction: Navy Conference Approval Process

Documentation is required for all conferences:

- » **Division Request Memo** – A memo requesting approval of the conference request that is signed by the Division Head and Associate Director of Research.
- » **Cover Memo to Department of Navy Assistant for Administration (DON/AA)** – A memo prepared for the Director of Research to sign to request approval for conference attendance from DON/AA.
- » **Conference Attendance Request** – An excel spreadsheet containing identifying information about the conference to include estimated costs and dates of travel.
- » **Agenda/Verification** – Documents from the conference organizer containing information about the conference, usually a challenge since the agenda and the technical content of the conferences in not decided this far ahead.

For conferences that cost \$100,000 or less – The NRL Directorates are required to submit requests eight weeks prior to the conference start date. These are reviewed and signed by the Director of Research and forwarded to the DON/AA, typically 30 days in advance.

There may be additional approval within the division section or branch level, being a working capital activity typically also have to get approval from the sponsor and their organization. Conferences and events with estimated expenses of over \$100,000 must go to the SECNAV for approval. The DON/AA keeps a running list of conferences anticipated to cost more than \$100,000 based on historical cost and participation information. The list is updated monthly and sent to the NRL.

Full submission documents must be submitted to the SECNAV at least 60 days prior to the start date of the conference. The DON/AA must receive the conference approval request 90 days prior to the start date of the conference.

personal signature for conference attendance approval. The Examples of Dysfunction box above illustrates the conference approval process in the Navy, which the Task Force found overly bureaucratic.

Another stark example of lack of local control are repairs and maintenance of Navy Labs and Centers. Repairs and maintenance are funneled through the Naval Facilities Engineering Command (NAVFAC), which has long backlogs and is not able to respond to lab needs in a timely manner. This creates a stalemate where the Lab has the need and the funding for a repair, but is

unable to act on it because the NAVFAC does not have bandwidth to let a contract and the lab does not have contracting authority.

The Task Force strongly believes the Lab and Center Directors ought to be empowered and encouraged to take responsibility for local matters. This will not only boost morale, but will also lead to better lab outcomes. ARL's Focus Campaign serves as an example of what can be achieved by the labs when local control is combined with vision and initiative. The ARL self-initiated the Focus Campaign to align their S&T portfolio with Army priorities and end lower priority programs. Portfolio turnover was approximately 30 percent over the last three years. The Focus Campaign necessitated significant cuts utilizing the following rubric: Each of the ARL's eight S&T campaigns took a 25 percent funding reduction based on priorities. Resources were then reallocated to the campaign area—not necessarily in the areas where the cuts occurred—up to 15 percent. The remaining 10 percent was then pooled and used for new starts across the entire portfolio. While the ARL recognizes the rubric will get harder to implement going forward, as most of the chaff has been identified and eliminated, the Task Force believes that similar self-initiated prioritization efforts will result in stronger research portfolios in the other Labs.

Measuring Performance for Success

The Labs utilize a large array of metrics to measure their performance. These metrics can be disparate and do not lend themselves to easy performance assessment and comparisons. The Task Force recognizes that, as the Labs and Centers themselves are diverse, it is challenging to define a global set of metrics. For example, while the number and citation statistics of conference and journal publications are an important indicator in a lab that performs basic research, it is hardly a relevant metric in a warfare center, whose purpose might be to transform a ship into a warship. However, the Task Force believes that some measurement is an essential component of Lab management. The metrics recommended below can be used by the Labs and others to measure and compare performance across the spectrum. Most of these metrics can be collected without creating undue administrative burden, for example by having each customer fill in a survey annually or at the delivery of a product or conclusion of a project. It is important these metrics should be anonymized and shared within the Lab community so individual labs can see how they compare to their peers.

- » **Overall Customer Satisfaction with Delivery.** The reputation and subsequent ability of the Labs to be present with a seat at the table depends on how their customers in the Services and ultimately the warfighters who benefit from their work perceive them. Understanding and responding to their customer needs is paramount for the Labs.
- » **Net Promoter Score.** What percentage of their customers would recommend the Lab to others?
- » **Permanent Staff Turnover.** Healthy organizations typically have an annual staff turnover in the low single digits. Zero turnover or turnover in the double digits should be both reasons for concern.

- » **Employee Engagement Index.** Employee surveys should be carried out annually to gauge morale and to understand strengths and weaknesses of the organization. If a Lab has consistently low scores of employee engagement or unusually high sick hours, it should be cause for concern.
- » **Products Delivered on Time and Budget.** Timely delivery is a critical success factor for the Labs, given the importance of transferring technology to the warfighter faster than our adversaries.
- » **Projects Delivered on Time and Budget.** Timely project delivery indicates ability not only to execute R&D but also ability to plan accurately.

4.2 Organizational Recommendations

- » Each of the Service Secretaries, through their respective Lab commands, should institute a systematic succession planning process for senior positions in the Labs including the Director.
- » In turn, the Lab Directors should institute meaningful employee appraisals (including 360 reviews and follow-up actions) and succession planning as part of a robust bench planning process.
- » The Lab Directors should strive to relieve the administrative burden from their staff, including conference approval processes.
- » The Lab Directors should self-initiate annual focus campaigns to manage their base funded priorities and enable investments in key new areas.
- » The Labs should adopt a uniform set of simple targets and metrics that can help them manage their performance. The ASD(R&E) should facilitate the anonymization and sharing of these metrics within the lab community as well as the Services and other stakeholders:
 - Overall customer satisfaction with delivery
 - Net promoter score
 - Permanent staff turnover
 - Employee engagement index
 - Products delivered on time and on budget
 - Projects delivered on time and on budget

5. Lab Readiness: Workforce

5.1 Findings

Talent Acquisition and Retention

Acquiring first-rate talent is an absolute imperative for the Labs. The Task Force found the Lab workforce is qualified, dedicated, and productive. Talent is attracted to the Labs due to the mission, the facilities, and the type of work. However, the Labs also face significant challenges in bringing in fresh blood across all experience levels: entry, mid-career, and senior. Additionally, it is difficult for the Labs to attract specialized, high-demand skills, such as data science and analytics.

At entry level, the Labs recruit at the local instead of the national level, partly due to the remote locations some of the Labs are based in and partly because the recruiting pipeline is not tuned to the national level. As a result, the Labs tend to hire scientists and engineers from local talent pools familiar with the Labs. The Task Force believes that there is an urgent need to broaden the Labs' reach by expanding and promoting internship programs and special initiatives like SMART.¹ By way of comparison, the Task Force heard companies invest very heavily in student internships. We heard that in the last five or so years, 80 percent of all computer science doctoral students in the top schools in the United States were known to Microsoft and had pursued an internship with the company at some stage of their education. Such programs give companies unparalleled access to the best and the brightest, whereas the Labs miss out by being absent. The Labs should prioritize and invest in building a robust presence at top universities and career fairs across the country. Through the Lab demo authority, the Labs have the ability to use specialized incentives, such as student loan debt forgiveness and more competitive compensation, to attract talent in areas of high demand. In addition, the Lab demo authority can be used to alleviate the lengthy delays associated with making offers and obtaining security clearances.

At mid-career and senior levels, there are challenges in terms of compensation, especially in areas of high demand such as computer science and cyber. The Labs do have the opportunity to reward their mid-career and senior employees by offering them interesting and challenging assignments and, in many cases, state-of-the-art facilities. That being said, the Task Force believes at the leadership level, there is a significant compensation disparity between the DoD and the Labs, which is materially reducing the pool of qualified candidates for leadership positions.

The Task Force also observed the Labs continue to rely on an aging workforce. While re-training existing personnel in new areas is certainly a possibility, it is not feasible to acquire the depth of expertise needed in emerging areas without accelerating hiring of specialists from the outside, especially at the entry and mid-career levels. The Task Force believes the Labs should encourage

¹ Science, Mathematics, and Research for Transformation (SMART) is a DoD scholarship for service program. The program pays all costs associated with the student earning a degree, Bachelors, Masters, or PhD in return for service within the DoD. Payment is 1:1 - one year of service for each year of scholarship.

workforce rotations with the private sector through incentive programs. This can help staff acquire much needed skills in a realistic business environment and bring them back into the Labs. Modern software development methods and practices such as agile or precise planning and estimation are a case in point.

Finally, the consolidation of hiring and internships through the USAJOBS portal is creating unique challenges for the Labs. It makes finding the right opportunity to apply for as easy as looking for a needle in a haystack. A potential doctoral employee from a top school being actively recruited and courted by private industry is very unlikely to have the perseverance to wade through scores of irrelevant opportunities to find and apply for an interesting role in a Lab he or she may have never heard of. Graduates who find these opportunities do so in spite of USAJOBS, not because of it. It is imperative the OSD creates an alternative Lab opportunity portal to assist the Labs in overcoming this handicap.

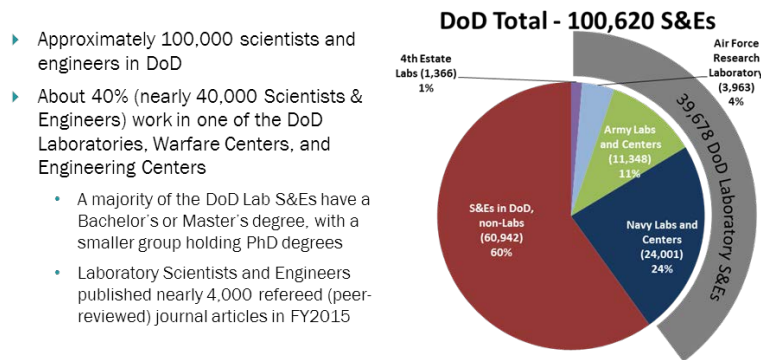


Figure 8. DoD Research and Engineering Workforce

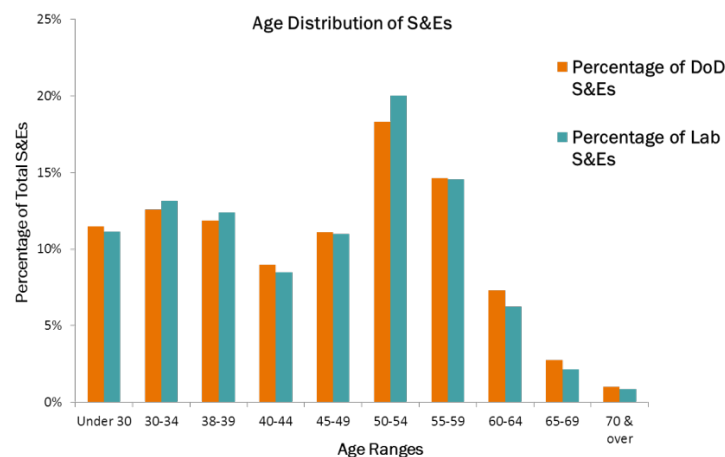


Figure 9. DoD Labs and Centers: Age Breakdown of the Workforce

Lab Demo Authority

The establishment of the Defense Laboratories Personnel Demonstration Projects in Section 342 of the FY95 NDAA (later renamed the Science and Technology Reinvention Laboratories (STRLS)), and also including all additional laboratories categorized as STRLs thereafter, was an explicit recognition the science and engineering (S&E) personnel in the laboratory environment comprise a unique workforce, requiring a different set of management principles, compensation, benefits, and evaluation criteria. Section 342 is commonly referred to as “Lab Demo.” The STRL system was designed to give Lab Directors greater flexibility and autonomy in determining the most appropriate mechanisms for managing their respective personnel, ensuring a quality S&T workforce capable of delivering the technologies and products necessary for maintaining a warfighter’s competitive edge. Providing Lab Directors with greater authorities to act independently in managing their own respective workforces was a way to ensure their Labs remained centers of innovation, with highly skilled and highly educated employees. The STRLs were designed to achieve a higher level of quality, both in the workforce and in their products.

Science and Technology Reinvention Laboratories

The OUSD(AT&L) maintains criteria for STRLs, set out in the DoD Instruction (DoDI) 3201.04, which includes:

- » S&E workforce principally involved in performing exploratory development or research work or a combination of both;
- » significant portion of staff should be S&Es performing exploratory development or research work;
- » R&D efforts are preferably in at least two well-defined specialty areas;
- » programmatic efforts are significantly technology-based (BA 1-7 work);
- » significant portion of R&D activities should be conducted in-house; and
- » at least one segment of the mission should be unique to the Lab or the Service.

5.2 Workforce Recommendations

- » Congress should authorize the Direct Hire statutory limitation under Section 1107(c) from 5 percent to 10 percent of the workforce.
- » The USD(P&R) should implement granted authorities within 90 days after authorization, unless otherwise exempted by Congress.
- » The ASD(R&E) should develop a specialized Lab job portal to allow qualified candidates to identify opportunities in a timely manner.
- » The Lab Directors should make maximum use of the authorities granted to them through the Lab Demo programs to provide market rate compensation and flexible rewards programs, growth opportunities, and regular bench strength development programs.
- » The Lab Directors should create a robust presence in career fairs in all top schools in the United States and not just those in their immediate vicinity.

- » The Lab Directors should encourage talent flow between Government and the private sector by implementing special programs such as spinouts and other entrepreneurial leave programs.

6. Lab Readiness: Infrastructure

6.1 Findings

Aging Infrastructure at Service Labs and Centers

The average age for an Army Lab is 50 years. Army MILCON focuses on shortfalls associated with Energy and Utilities, Organic Industrial Base, Organizational Vehicle Maintenance, Reserve Component Readiness Facilities, and Trainee Barracks and Training Support Systems – not laboratory infrastructure.

The AFRL facilities have a slightly younger average age of 45 years. The Air Force's recent consolidation of laboratories at co-located campuses has enabled updates and modernized infrastructure. In the long-term, success requires a considerable investment,

including the use of military construction funds. Additionally, the AFRL is addressing the aging infrastructure. The 2005 BRAC included over \$400 million in facility recapitalization investment.

While the Navy's Labs have an average age of 46 years, the infrastructure of naval laboratories is aging and facility improvements are necessary. A Naval Infrastructure Capabilities Assessment (NICAP) effort was completed in FY14, which included all RDT&E capabilities at the Warfare and Systems Centers. NICAP captured and baselined technical information on more than 500 different capabilities spread across 68 different geographical locations of the 15 Laboratory and Warfare and Systems Centers.

Funding Laboratory Infrastructure

Infrastructure is top of mind for all Lab Directors. With the exception of the AFRL, which benefited significantly from the 2005 Base Realignment and Closure (BRAC), most Lab Directors feel they are unable to maintain their facilities and infrastructure to a reasonable standard. The Task Force witnessed both state-of-the-art facilities (including the ARL Open Campus facilities at Adelphi and Santa Monica) as well as many run down ones (i.e., leaky roofs imperiling millions of dollars' worth of specialized and sensitive equipment). Challenges include sustainment of facilities' capabilities, restoration of non-functional facilities and equipment, modernization of outdated facilities and infrastructure, and competition with other Service priorities.

Funds for infrastructure construction, maintenance, and repair can come from a variety of sources: major military construction (MILCON), minor military construction (mainly Section 219 funds), BRAC, Section 2803, or alternative or third party financing under the Enhanced Use Lease (EUL) Authority 2667. There are challenges with all of these. Major MILCON pits Labs in competition with broader Service needs, such as daycare centers and other facilities, and the Labs

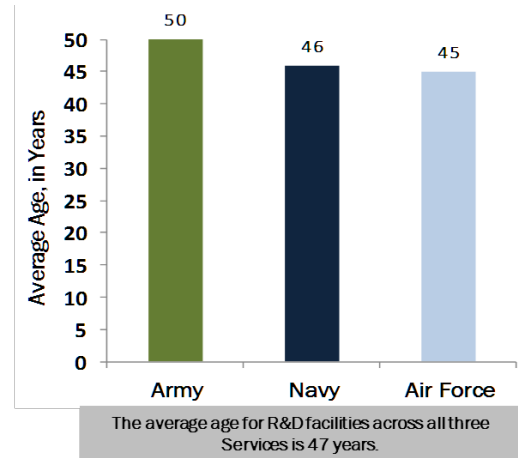


Figure 10. Average Age of R&D Facilities

rarely win. Section 219 is a lifeline, but in the Navy it is limited to one percent as opposed to three percent. The Labs cannot carry over funds from one fiscal year to the next to allow funding for larger projects. BRAC comes infrequently and not all Labs are able to participate. Section 2803 is not exercised by Lab Directors because it is an authority to spend \$150 million without an accompanying appropriation, thus necessitating re-appropriation of funds.

Enhanced Use Lease

The Enhanced Use Lease (EUL) is a tool to more effectively use underused property to benefit installations. It leverages currently available DoD assets. The EUL allows the installation to receive rent in cash or in-kind services no less than fair market value of asset.

The EUL is neither the sale of installation land nor a partnership with a selected developer. The Lab or the Service does not contribute equity into the project and do not make a guarantee of revenue to the developer; all associated risks are assumed by the developer.

Title 10 USC Section 2667 gives the Services authority to enter into long-term or short-term leases of underutilized, not excess real property or to lease land and/or buildings; receive consideration, either as rent payable to the Government, or as in-kind consideration, which can be used to fund other facility projects and does not have to be invested in the leased property.

Types of in-kind consideration include maintenance, protection, alteration, repair, improvement, or restoration (including environmental restoration) of property or facilities under the control of the Secretary concerned and construction of new facilities for the Secretary concerned, provision of facilities for use by the Secretary concerned, provision of such other services relating to activities that will occur on the leased property as the Secretary concerned considers appropriate.

The EUL Authority utilization at the Labs can be a challenge due to the difficulties in forecasting long-term infrastructure capability needs and requirements. Additionally, approval processes for a Lab can be cumbersome due to a Service's internal MILCON prioritization processes.

Examples of Dysfunction: Repair Electronics Science and Technology Lab Building 65/75 at the NRL

- » Special Project RM 12-2756, Repair Electronics Sciences and Technology Lab. Original Estimate: \$35.3 million (\$33.0 million for Repair and \$2.3 million for Construction).
- » Built in 1945 and 1953, significant repair and restoration necessary for laboratories and work spaces; minor construction to expand utility systems and meet research demands.
- » Final project approved and contract bids received but all work was put on hold because during the process of preparing the Congressional notification release, the Assistant Secretary of the Navy for Financial Management and Comptroller (ASN (FM&C))/ and the Financial Management Budget (FMB) stopped the project, declaring it a MILCON.
- » FMB if both repair costs (restores a facility so it may be used for its functional purpose) and construction costs (increases the capacity of the utility systems) each portion must produce a complete and useable project.
- » Contrary to opinions of facility and legal experts at the NRL, the NAVFAC, Command, Navy Installations Command (CNIC), and the Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN(RDA)) as well as congressional language indicating repair and construction work can be done concurrently as long as the resulting project is complete and useable.
- » FMB inserted MILCON Project P-275 – Electronics Science and Technology Laboratory that renovates Buildings 65/75 into POM15 by transferring NRL customer funds reducing NRL NWCF rates. Total Funded Amount \$31.7M (FMB made a 10 percent “cost savings reduction”).
- » Bids were received December 17, 2015. Low bid for total scope: \$60.3M. Including NAVFAC supervision and inspection plus contractor change order costs, total required funding is \$66.8M.
- » On March 9, 2016, NAVFAC Washington signed a MILCON reprogramming request and justification for additional \$35.1 million to NAVFAC HQ via NAVFAC Atlantic. No funds have been identified for reprogramming to this project.
- » Current Status – As of September 2016, additional funds were not identified, full funding not likely. The NRL project still appears below the funded amount so it may have to significantly reduce the scope (complete redesign - 18 months - then award construction project in late FY18) or cancel the project.

Examples of Dysfunction: NAVSEA Warfare Centers

- » NAVFAC Washington is understaffed with acute deficiency areas including heating, ventilation, and air conditioning/digital data control (HVAC/DDC) technicians, electrical, and maintenance mechanics, engineers, architects, technicians, and contracting officers/specialists.
- » NAVFAC Washington has insufficient “standing” acquisition contracts to execute customer work on schedule.
- » Regional NAVFAC electrical rates are too volatile, causing significant impact to Warfare Center Division costs. The materials procurement process timeframes (Supply Chain Management) impact NAVFAC’s ability to execute shop maintenance and repair work promptly. The Facility Condition Indices are based on dated and incomplete information and do not sufficiently consider facility and facility system age
- » **Bottom Line:** Lab roof leaks, Lab has the funding to fix it but is unable to do so because they lack the contracting authority and have to go through NAVFAC, which is overwhelmed with backlog.

Infrastructure challenges

The Task Force found examples of dysfunction regarding infrastructure planning and operation. Perhaps the most disturbing case of facilities issues the Task Force became aware of was at Eglin AFB, where 15 researchers working on the C86 laser had no potable water for eight months between November 2015 and June 2016. While Google style cafeterias are an extravagance no one in the Labs would expect, Lab researchers are certainly entitled to drinking water at their place of work.

In contrast, the Task Force wants to highlight an example of significant facilities project in the Defence Science and Technology Laboratory (DSTL) in the United Kingdom. The leadership of the Lab determined it was best they should close their Fort Halstead site and consolidate facilities in Porton Down at a cost of approximately \$140 million through an internal consultation and planning process. They were able to manage this very large project within their own means as part of a 10-year capital planning process. A project of such scale would have been virtually impossible for one of our Labs to execute within the constraints they operate with without a BRAC. The limit for any project under Section 219 is \$4 million and funds cannot be carried over year over year.

Examples of Success: DSTL Helios Project

- » DSTL decided to consolidate their Fort Halstead site with their Porton Down facility through an internal process.
- » This required building new energetic material facilities to accommodate activities transferring from Fort Halstead at a total cost of £115 million, handled through DSTL's 10-year capital planning process.



6.2 Infrastructure Recommendations

- » The Service Secretaries should ensure Section 219 is applied uniformly and at three percent of all funds available to the Labs (four percent, if authorized by FY17 NDAA).
- » The Lab Directors should fully exercise the authorities granted to them, particularly through Section 2803.
- » The Navy Lab Directors should be given authority to let contracts for up to \$500,000 per project in order to overcome the NAVFAC bottlenecks.

- » The DoD Comptroller should create accounts to allow Labs to bank Section 219 funds from year to year to be able to fund projects that exceed \$4 million under their own steam instead of waiting for elusive MILCON funds.
- » The Assistant Secretary for the Army (ASA) for Installations, Energy, and Environment should work with the Labs to create opportunities for them to utilize EUL Authorities (2667) when the physical location of the Lab is conducive (i.e., in metro areas).

7. Lab Readiness: Collaboration and Working with Others

While the Labs are individually strong and are making significant contributions, they can multiply their impact by working together and by collaborating with others.

The Task Force found while there is significant cooperation between the Labs already, there are further collaboration opportunities to build a strong, effective, and efficient technology maturation pipeline for the Department.

7.1 Findings

Collaborating with Each Other for More Effective Outcomes – Reliance 21 Communities of Interest

Reliance 21 is the overarching framework of the DoD's S&T joint planning and coordination process. The goal of Reliance 21 is to ensure the DoD S&T community provides solutions and advice to the Department's senior-level decision makers, warfighters, and other stakeholders as well as Congress in the most effective and efficient manner possible. This is achieved through an ecosystem and infrastructure that enables information sharing, alignment of effort, coordination of priorities, and support for scientists and engineers across the Department.

Reliance 21 has roots that go back several decades and has been continually renewed and refreshed to ensure relevance as circumstances have evolved. This emphasis on coordinated research planning is a key strength of DoD's S&T enterprise. The strength of Reliance 21 is demonstrated in the cross-cutting collaborative teams that provide strategic and technical leadership of the S&T workforce.

Reliance 21 is led by the S&T Executive Committee (ExCom), chaired by the ASD(R&E), and comprised of the major DoD S&T organizations. The ExCom prioritizes resources and provides strategic oversight and guidance to the combined S&T workforce, Labs, and facilities. Supporting the ExCom leadership is an ecosystem of technical groups known as the Communities of Interest (COIs). The 17 COIs span the cross cutting S&T areas within the DoD. The collection of COIs serves as an enduring structure to integrate technology areas throughout the DoD S&T enterprise. While they cover the majority of the DoD's S&T investment, some Service-specific investments are not included in this group. This is a potential area for change: Reliance 21 could be broadened to include all S&T investments, including the Service-specific efforts presently excluded.

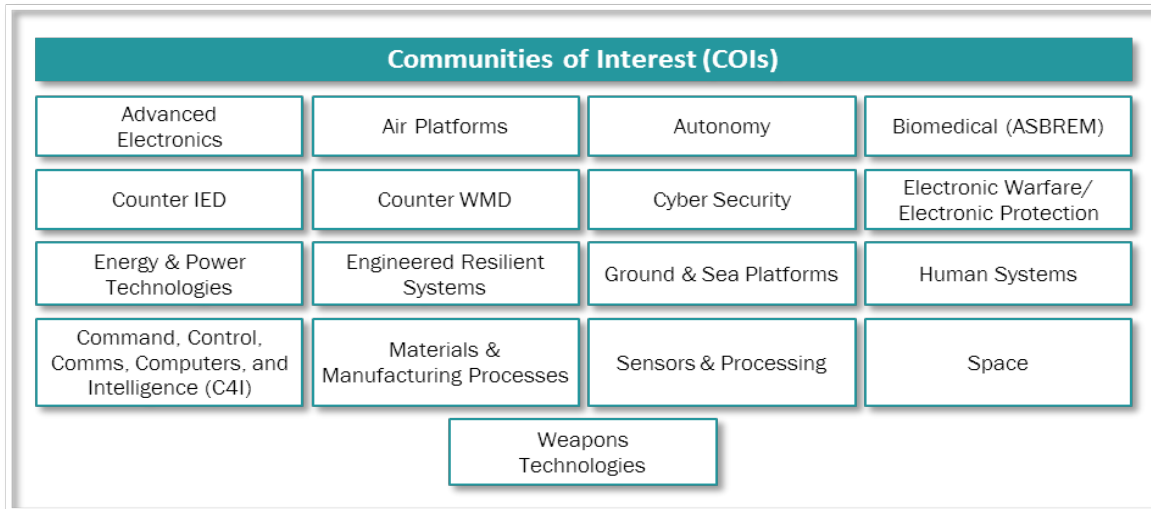


Figure 11. Reliance 21 Communities of Interest

Communities of Interest

- » COIs were established in 2009 as a mechanism to encourage multi-agency coordination and collaboration in cross-cutting technology focus areas with broad multiple-component investment. COIs provide a forum for coordinating S&T strategies across the DoD, sharing new ideas, technical directions, and technology opportunities, jointly planning programs, measuring technical progress, and reporting on the general state of health for specific technology areas.
- » Each COI is led by a steering group comprising senior technical leaders with common technology interests, drawn from the Services, the Joint Staff, the Defense Agencies, the OSD, and the acquisition community, if appropriate. They are organized with an appropriate breakdown of sub-groups, in a fashion that best serves each technology area. These groups are populated by subject matter experts from across the DoD, who often have decades of experience in the DoD S&T research enterprise and are an asset in the DoD's efforts to generate technology surprise and deliver operational capabilities.
- » The COI technology areas will not change substantially from year to year. However, they are regularly reviewed by the S&T ExCom and the S&T Deputies Council, who may constitute new groups or retire existing groups in response to major changes in DoD strategy or investment decisions.
- » The principal outputs of COIs are strategic plans and roadmaps with a 10-year horizon to capture technical goals and mission impact. Their analyses identify common S&T needs and show where they are being addressed or where there are gaps or future opportunities. These plans are used to guide long-term budget decisions and to influence near-term program priorities in each of the components.
- » COIs work closely with program executives and warfighters throughout the DoD, including supporting the Joint Staff in identifying potential solutions to warfighter needs. COIs are also expected to coordinate international S&T engagement for their technical area, taking components strategic objectives into account.
- » The activities of the COIs are considered mission-critical to the effective conduct of the DoD's S&T program. COI members will need to travel and conduct meetings, workshops, and attend conferences in person, although the COI/S&T collaboration infrastructures should first consider video teleconferences and other alternatives if they can be used effectively.
- » Collaborating with each other to lead the DoD in big technology shifts.

Laboratory Quality Enhancement Program

The FY17 NDAA Section 211 formally established the “Laboratory Quality Enhancement Program” to:

- » Review and make recommendations to the Secretary with respect to:
 - existing policies and practices affecting the science and technology reinvention laboratories to improve the mission effectiveness of such laboratories; and
 - new initiatives proposed by the science and technology reinvention laboratories.
- » Support implementation of current and future initiatives affecting the science and technology reinvention laboratories.
- » Conduct assessments or data analysis on such other issues as the Secretary determines to be appropriate.

Through this governing body, the Lab Directors will be able to make recommendations to carry significant weight and influential within the DoD. It brings them together to address big agenda items for the department, such as the preponderance of software in defense system, and sharing of unique facilities to develop DoD enterprise-wide unique view.

Working with the Defense Advanced Research Projects Agency

The Defense Advanced Research Projects Agency (DARPA) is charged with disruptive and over-the-horizon R&D. The Labs work closely with DARPA typically in the role of performer or contract monitor. While both of these roles are useful, there is a gap between DARPA and the Labs the Task Force feels needs to be bridged. The Labs are critical technology maturation and transfer partners for DARPA and can help the Agency get technologies proven and transferred to the hands of the warfighter expeditiously. The Task Force feels the Labs ought to forge a closer relationship with DARPA, to form a partnership that is critical for national security. We recommend at least the corporate Labs (the ARL, the NRL, and the AFRL) should have key personnel billeted to DARPA much the same way the Services have representatives stationed at the Agency.

Warfare Center to Laboratory Collaboration

The Navy’s Warfare Centers and Systems Centers enjoy a strong partnership and collaboration with the Office of Naval Research (ONR) and the NRL. A great example of this partnering is the electromagnetic (EM) railgun.

The ONR has served as a primary sponsor of the Navy’s railgun efforts. The NSWCDD has performed full-scale RDT&E of the Navy’s railgun. This has included the operation of a major test facility, pulsed power development, EM gun design, projectile development, and shipboard integration.

The NRL is focused on basic research in support of the railgun program. The NRL scope is focused on three areas: material science research into armatures and rails to understand fundamental science of in bore performance; development of new and innovative instrumentation techniques

to monitor in-bore physical properties of materials, electric fields, and magnetic fields; and operation of a smaller scale railgun to support cross laboratory validation between NSWCCD and NRL test activities.

ARL South focus on biological materials complements current Tri-Service Research Laboratory (TSRL) projects.

Collaboration between ARL and the Tri-Service Research Laboratory

- Gives Army laboratories a path for bringing successful biotechnology projects into secure environment for maturation and application-specific development
- Opportunity for quick-wins by leveraging TSRL expertise, infrastructure and programs
- Introductions to relevant research and development community throughout Texas
- Currently establishing MOA between ARL and AFRL



ARL South (Open Campus)

- Planned Start: late 2016
- Primary location under negotiation
- Broader personnel recruitment base
- Increased innovation through collaboration
- Enhance existing relationships with academia & industry

Figure 12. ARL South/TSRL Collaboration

7.2 Collaboration Recommendations

- » The Lab Directors should detail Lab personnel on rotation to DARPA as the Services do. The Labs can be invaluable technology transition partners for DARPA.
- » The ASD(R&E) should increase the aperture of Reliance 21 to look beyond the S&T enterprise:
 - Encourage greater alignment and collaboration.
 - Share resources and facilities.
 - Encourage cross organization details.
 - Convene annual Lab Director summits to encourage alignment and collaboration.

8. The OSD and the Labs

The Labs operate inside a large and complex defense enterprise. A back of the envelope analysis shows 19 layers between a Lab individual contributor scientist and the Secretary of Defense. By way of comparison, the United Kingdom's DSTL Chief Executive is three layers removed from the Secretary of State for Defence. More broadly, the framework within which the Labs operate is not optimized for them, but rather for the Services they are part of. While there are clear benefits to having the Labs embedded in the Services (i.e., technology transfer and portfolio alignment) there are also significant drawbacks. Consider, for example, the complexity of acquiring highly specialized R&D equipment within an acquisition framework optimized for buying weapons platforms. In a more startling example, a 2016 report prepared by the Pentagon for Congress recommending a BRAC, suggested there is a 46 percent excess capacity in the Army Test and Evaluation Labs on the basis of a ratio calculated by taking into account the size of the future Army and the test acreage they would need for training, a metric clearly irrelevant to Lab capacity.

8.1 Findings

The OSD Better Buying Power 3.0 and the Labs

The goal of Better Buying Power (BBP) 3.0 is to achieve dominant capabilities through technical excellence and innovation. BBP 3.0 aims to strengthen cost consciousness, professionalism, and technical excellence in DoD acquisition. The Labs are an integral part of that process and should be tasked with specific actions by the OSD. Smart buyer, technology transition, open innovation, technology leadership, and technology defense are all essential elements of acquisition excellence. In other words, as opposed to considering the Labs merely as technology producers, the DoD can use the Labs to further its BBP objectives.

Department Engagement with the Labs

A perception exists that Congress cares more about the Labs than the OSD does. There is also a sense the Labs are perceived as being behind the curve and are not valued as the assets they are. The Department needs to strengthen its engagement with and guidance to the Labs. For example, there is often too wide a gulf between what the operator needs and the technologists in the Labs. One way to address this gap is for the Services to drive the Labs with a challenge problem (e.g., how do you make Apaches last for 100 years?). The third offset strategy can also be a unifying vision that can help the Labs focus and align their work with the warfighter needs.

Advocacy for the Labs

Advocating for mission impact of the Labs can be a challenge, but the payoff is extremely valuable. Programs can be reluctant to be held accountable for achieving missions they do not have direct control over. Organizational incentive structures generally reward program efforts (i.e., what the program does) rather than program effects (i.e., what difference has the program made). Calculating the return on investment of the Labs is also extremely challenging. Developing data collection methods for assessing external effects is likely to be labor and resource intensive. While the metrics we are recommending will at least partially address this issue, it is also important the

ASD(R&E) advocates on behalf of the Labs by creating and sharing a narrative explaining the work and the impact of the Labs in plain language on a regular cadence.

8.2 Recommendations on the OSD and the Labs

- » The USD(AT&L) should revise issued guidance to incorporate specific actions the Labs need to take to support the BBP 3.0 initiative.
- » The ASD(R&E) should create transparency on its responses to Lab-related Congressional actions by publishing an account of implemented actions.
- » The ASD(R&E) should champion an effort to describe impact to raise awareness of the importance of the Labs as a unique catalyst for innovation:
 - Quarterly “brag sheets” for:
 - ▶ internal DoD stakeholders;
 - ▶ external stakeholders, such as members of Congress, policymakers, and other federal entities; and
 - ▶ the American public.

8.3 Recommendations Recap

The next section is a recap of recommendations regarding the use of authorities by the Labs.

Authorities Recommendations

- » Section 219 should be applied uniformly and at three percent of all funds available to the Labs.
- » The DoD Comptroller should create accounts to allow the Labs to bank Section 219 funds from year to year to enable them to fund projects exceeding \$4 million under their own steam instead of waiting for elusive MILCON funds.
- » Rather than wading through the Federal Register Notice processes, the USD(P&R) should implement granted authorities within 90 days after authorization, unless otherwise exempted by Congress, while concurrently seeking Federal Register Notice publication.
- » Conference approval processes should be devolved to the Lab Directors and should be consistent across all Services.
- » The ASA for Installations, Energy, and Environment should work with the Labs to create opportunities for them to utilize EUL Authorities (2667) when the physical location of the Lab is conducive (i.e., in metro areas).
- » The ASD(R&E) should ensure the Services and the Lab Directors use the full set of authorities available.
- » Congress should actively monitor the implementation of granted authorities.

The Task Force felt the Navy is creating a particularly onerous operating environment for its Labs which is in many ways out of line with the practices followed by the other services. The next section is a recap of Navy-specific recommendations.

Navy Specific Recommendations

- » The SECNAV should ensure the Navy Labs and Centers have a stable and adequate mission fund.
- » The SECNAV should authorize Lab Directors to use up to three percent of Section 219 funds, four percent if authorized in FY17 NDAA.
- » The SECNAV should give Navy Lab Directors authority to let contracts for up to \$500,000 per project in order to overcome the NAVFAC bottlenecks.
- » The SECNAV should devolve conference approval to Lab Directors.
- » The NRL Director should ensure the NRL participates in the SMART program.
- » The NRL Director should ensure the NRL develops competency to use Other Transactional Authorities (OTAs).

9. Congress and the Labs

9.1 Findings

The Task Force found that Congress has been consistent in its support and advocacy for the Labs. The legal framework created by the totality of authorities granted to the Labs by Congress goes a long way towards alleviating the complexities and mismatches between what the Labs need in order to succeed and what would otherwise be available to them. The Task Force believes that the continued support and championship of the Labs by Congress will be essential for their success.

Management Demo: A Pilot Program

At the DoD S&T Labs, the Director of Labs may carry out the pilot program called the Management Demo. They assess feasibility and advisability of enhancing operations and personnel management of such Labs through waiver of regulation, instruction, publication, policy, or procedure. The Lab Director proposing to grant a waiver submits to Service Secretary and the General Counsel of said department.

At DARPA, the Director may carry out pilot program by assessing feasibility and advisability of enhancing operations and personnel management of such through waiver of one or more regulation, instruction, publication, policy, or procedure. The Director of DARPA submits a waiver proposal to Chief Management Officer of the DoD and the General Counsel of the DoD justification for each waiver proposed to be issued by the Director under program.

Directors place priority on waiver of regulations, instructions, publications, policies, or procedures relating to operations and personnel management relating to facilities management, construction, and repair, business operations, human resources, and public outreach. Waivers are proposed to go into effect at end of a 30-day period, beginning on date of receipt by Service Secretary or the Chief Management Officer, where applicable. Authority to grant waivers expires December 31, 2023. Nothing shall act to terminate waiver granted before that date.

Important STRL Legislation

- » FY95 NDAA
 - The DoD STRLs authorized to establish demonstration projects.
 - "...shall be similar in nature to the China Lake demonstration project."
- » FY01 NDAA
 - Transferred control and approval authority of STRL demo projects from the Office of Personnel Management (OPM) to the OSD.
 - "...the Secretary shall exercise the authorities granted to the Office of Personnel Management under such section 4703."
- » FY04 NDAA
 - STRLs excluded from National Security Personnel System (NSPS).
- » FY08 NDAA
 - Provided for full implementation of demo authorities, made all authorities available to all Labs and required annual Congressional report.
- » FY09 NDAA
 - Provided direct hire authority for candidates with advanced degrees to STRLs.
- » FY10 NDAA
 - Added new STRLs, repealed NSPS, and required Congressional approval to convert a STRL to a personnel system other than Lab Demo.
- » FY11 NDAA
 - Increased direct hire allocations for candidates with advanced degrees to STRLs.
- » FY12 NDAA
 - Removed sunset clause for advanced degree direct hire authority.
- » FY14 NDAA
 - Provided direct hire authority for bachelor degree and veteran STEM candidates.
 - Provided authority to create above GS-15 positions (Senior Science and Technology Managers or SSTMs).
 - Provided for exclusion from personnel limitations: manage to budget.
- » FY15 NDAA
 - Added two additional STRLs.
 - Provided direct hire authority for STEM students.
- » FY16 NDAA
 - Provided student direct hire conversion authority.
 - Authorized a pilot for dynamic shaping of the STRL workforce.
 - Flexible term appointments.
 - Reemployed annuitants.
 - VERA/VSIP.

9.2 Recommendations on Congress and the Labs

- » The Task Force strongly supports the motivation behind the proposed Management Demo Program (Section 948) and urges Congress to pass the legislation.
- » Congress should act to extend Lab Demo authority (Section 1107) to all Labs (see Section 5.1 of this report for more details on Lab Demo).

10. Conclusion

The Task Force encountered proud, dedicated people who have made the defense of our country through technology their life's purpose. The Task Force strongly applauds them. We also recognize they do their work in a challenging environment while on occasion suffering from self-inflicted injuries.

To maintain and enhance their value proposition, the Labs need to embrace open innovation and technology defense as an integral part of their mission. The Labs also need to lead the DoD through fundamental technology shifts by being able to anticipate and canvas emerging and future requirements and evolving warfighter missions. There needs to be expanded coordination among intermural basic research portfolios across the Labs without creating additional administrative burden.

In turn, the DoD (the OSD, the Services, and the Combatant Commands) needs to actively engage in the evolution of the Lab enterprise. Congress needs to continue working with the DoD to simplify the regulatory environment in which the Labs operate; yet, the Labs need a culture shift to utilize the authorities already granted— they should be aware of them and willing to use them.

Perhaps most importantly, the Labs need to be more active and at the table in the DoD requirements definition process. To achieve this, they have to be both present and credible by focusing their portfolios on the capabilities that will be needed by the warfighter today and tomorrow. They have extensive and growing authorities at the disposal they ought to leverage to carve a productive path through the complex environment they operate in. Building a spirited culture of self-reliance will be essential for their success and their ability to support our forces fighting the good fight.

THIS PAGE LEFT INTENTIONALLY BLANK

Appendix A – Task Force Terms of Reference



ACQUISITION,
TECHNOLOGY,
AND LOGISTICS

THE UNDER SECRETARY OF DEFENSE

3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

FEB 18 2016

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference–Defense Science Board Task Force on Defense Research Enterprise Assessment

The 2015 National Defense Authorization Act directs the Secretary of Defense to task the Defense Science Board (DSB) to conduct an assessment of the organization, missions, authorities, and health of the defense research and development enterprise. This enterprise consists of 62 Department laboratories across 22 states and the associated workforce of over 65,000 employees, of which approximately 36,400 are degreed scientists and engineers. These people and facilities are critical in maintaining the technological edge of the Department of Defense and providing the necessary tools for the Warfighter. Questions remain about the Department of Defense's internal lab infrastructure, especially compared to academic, industrial, and international counterparts, and the ability of the Department's labs to attract and retain a workforce with the necessary skills.

This study will assess the condition of the Department of Defense research and development enterprise. Specific questions for the study to address include: How well do the defense laboratories respond to the needs of the Department? What mechanisms exist to refurbish and recapitalize Department of Defense labs, and how do those mechanisms compare with other Government, academic, international, and industrial counterparts? How well does the Department attract, recruit, retain, and train its workforce to remain technically current and flexible to respond to emerging national requirements? Does the appropriate balance exist in each service between service control and laboratory director discretion so as to maximize laboratory mission effectiveness?

I will sponsor the study. Dr. Victoria Coleman will serve as chair of the study. Dr. Jagadeesh Pamulapati will serve as Executive Secretary. Lt Col Victor Osweiler, USAF, will serve as the DSB Secretariat Representative.

The study will operate in accordance with the provisions of P.L. 92-463, "Federal Advisory Committee Act," and DoD Directive 5105.04, "DoD Federal Advisory Committee Management Program." It is not anticipated that this study will need to go into any "particular matters" within the meaning of title 18, U.S.C., section 208, nor will it cause any member to be placed in the position of action as a procurement official.

Frank Kendall

Appendix B – Task Force Membership

Chair

Dr. Victoria Coleman

Members

Dr. Ruth David

Dr. Joe Markowitz

Dr. Bill Schneider

Dr. Jim Tegnalia

Government Advisors

Dr. Chris Fall

Mr. Kris Gardner

Dr. Kurt Preston

Dr. Garrett Polhamus

Dr. GP Sandhoo

Mr. Dale Sisson

Executive Secretary

Dr. Jag Pamulapati

Defense Science Board Secretariat

Karen Saunders	Executive Director
CAPT Jeffrey Nowak, USN	Deputy for Operations
CAPT Hugh M. Flanagan, USN	Deputy for Operations (prior)
Lt Col Victor Osweiler, USAF	Deputy for Operations (prior)

Study Support

Sarah Gamberini	SAIC
Brenda Poole	SAIC
Kathleen McGlynn	SAIC
Mary-Anne Gillis	SAIC

Appendix C – Briefings Received

25-26 April 2016 – Task Force Meeting

Congressional Panel <i>House and Senate Armed Services Committees</i>	Lab Director Panel <i>Army Research Laboratory; U.S. Army Engineer Research and Development Center; Navy Research Laboratory; Air Force Research Laboratory</i>
Deputy Assistant Secretary of Defense Research <i>Deputy Assistant Secretary of Defense for Research</i>	Navy Lab Assessment <i>Deputy Assistant Secretary of the Navy for Research, Development, Technology, and Evaluation</i>
Department of Homeland Security, Science and Technology <i>Department of Homeland Security Advanced Research Projects Agency</i>	Cost Assessment and Program Evaluation Office of the Secretary of Defense, CAPE

24-25 May 2016 – Laboratory Visits

Air Force Research Laboratory Overview <i>AFRL</i>	Metals Additive Manufacturing <i>AFRL/Materials and Manufacturing</i>
Human Capital <i>AFRL/Capability Lead</i>	Hypersonics <i>AFRL/Aerospace Systems</i>
Lab Demo <i>AFRL/Directorate of Personnel</i>	Senior Leader Discussion <i>AFRL</i>
Military Construction <i>AFRL/Plans and Programs</i>	Windshield Tour of Facilities – Public Affairs Office <i>U.S. Army Engineer Research and Development Center</i>
Section 219, CRDF Discussion <i>AFRL</i>	Computational Hydrodynamics <i>ERDC/Coastal and Hydraulics Laboratory</i>
Discussion with Researchers <i>AFRL/Aerospace Systems; Materials and Manufacturing; Sensors; Munitions; Directed Energy; 711 Human Performance Wing; Information</i>	Ship Tow Simulator <i>ERDC/Coastal and Hydraulics Laboratory</i>
Vigilant Spirt <i>AFRL/711 Human Performance Wing</i>	Materials Research <i>ERDC/Geotechnical and Structures Laboratory</i>
BATMAN <i>AFRL/711 Human Performance Wing</i>	Infrasound <i>ERDC/Geotechnical and Structures Laboratory</i>

Tunnels
*ERDC/Geotechnical and Structures
 Laboratory*

New Hires, Executive Level Group (ELG),
 DBIVs Discussion
ERDC

Blast Load Simulator/Blast/Force Protection
ERDC

High Performance Computing Tour
ERDC/Information Technology Laboratory

Engineered Resilient Systems
ERDC/Information Technology Laboratory

1-3 June 2016 – Laboratory Visits

Quantum Science and Engineering Army
 Readiness Assessment Program (ARAP) and
 NRL Activities in Quantum Information
 Science and Engineering
Navy Research Laboratory

Software Assurance
NRL

Millimeter Wave Power Sources
NRL

Spintronics in Epi Center
NRL

Space Robotics
NRL

EW for Pacific and Eastern Med. Theate
NRL

Large Angle Spectrometric Coronagraph
 (LASCO) and Sun Earth Connection Coronal
 Heliospheric Investigation (SECCHI): Space
 Weather Monitors
NRL

Young and Mid-Career Level Scientist Social
NRL

Rail Gun Demo
NRL

Large Displacement Unmanned Underwater
 Vehicle (LDUUV); Flying Sea Glider/Close-In
 Covert Autonomous Disposable Aircraft
 (CICADA); UXV's for Chemical and Biological
 Detection

*NRL/Laboratory for Autonomous Systems
 Research*

Synthetic Biology/Bio Molecular
NRL

Low Frequency Broad Band
NRL

Bio Printing
NRL

Corrosion Research and Development Lab
 Tour
NRL

Research Facilities
NRL

NRL Senior Management Session
NRL

Naval Surface Warfare Center – Dahlgren
 Division Command Overview
*Naval Surface Warfare Center – Dahlgren
 Division*

Senior Leadership Discussion
NSWCDD Senior Leadership

Battle Management System Walk-through
NSWCDD

Directed Energy (LaWS)
NSWCDD

Laser Lethality Lab Demo
NSWCDD

Railgun Facility Tour
NSWCDD

Poster Session
NSWCDD

Army Research Laboratory Overview and
Open Campus
Army Research Laboratory

Overview of the Network Science Research
Laboratory
ARL/Network Science Research Laboratory

Neuro Realtime Brain Monitoring
ARL/NSRL

Networks and Information Science
International Technology Alliance
ARL/NSRL

Walk by – Specialty Electronics and Sensors
Cleanroom
*ARL/Specialty Electronic Materials and
Sensors Cleanroom*

Piezoelectric Micro-Electro-Mechanical
System and Position, Navigation, and Timing
*ARL/ Specialty Electronic Materials and
Sensors Cleanroom (SEMASC)*

Battery Dry Room – High Voltage Li-ion
Batteries
ARL

Early and Mid-Career Social
ARL

Senior Leaders Discussion
ARL

23-24 June 2016 – Task Force Meeting

Navy Brief
*Chief of Naval Research Director,
Innovation, Technology Requirements and
Test and Evaluation*

Defence Science and Technology Labs
UK Ministry of Defence

Industry Hiring Practices
Google/Microsoft

Defense Advanced Research Projects
Agency Brief
Defense Advanced Research Projects Agency

Facilities Brief
*Naval Sea Systems Command Warfare
Centers*

Australian Defence Science and Technology
Laboratories
Australian Department of Defence

Open Campus Brief
ARL

Labs and the Intelligence Community
*Director of Science and Technology
Acquisition, Technology and Facilities/ODNI*

Installations Briefing
*Deputy Assistant Secretary of Defense for
Facilities, Investment, and Management*

Appendix D – Past Studies

» Previous studies, recommendations, actions & inaction

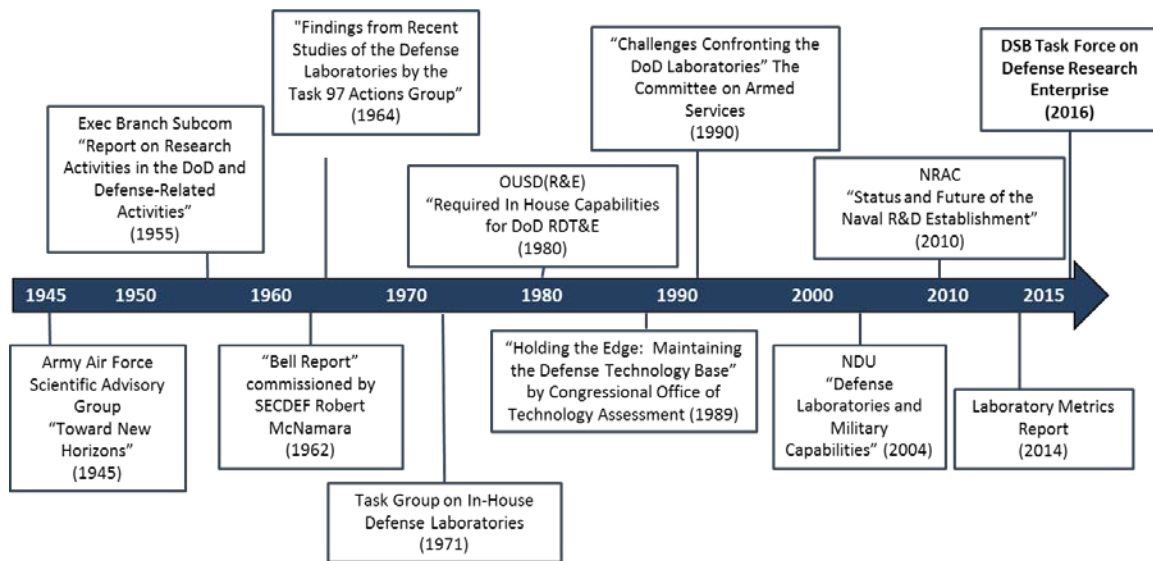


Figure D-1. 200+ Studies, Assessments, and Reviews of the DoD In-House Laboratory Systems Have Been Conducted Over This Period

Common Themes in Past Studies

Most studies aim to improve, not criticize, the quality of in-house S&T and widely recognize them as essential. Many reports cite the high quality and utility of in-house S&T and the Labs and Centers. Several studies recommended decentralization of management. Numerous recommendations for improving in-house S&T and facilities appear repeatedly. Many issues under consideration by the present study effort are at least 70 years old.

While some, but not sufficient, actions were taken in response:

- » The AFRL consolidated 13 labs into four "superlabs" (1990)
- » The AFRL further consolidated the four "superlabs" to one lab (1997)
- » The NRAC proposed Navy Laboratories Center Coordinating Group (2010)
- » The Army consolidated seven corporate labs into Laboratory Command (1992)
- » The Creation of Reliance 21- A framework for joint planning and coordination for DoD's S&T community (2014)

Challenges of adopting study recommendations

The DoD's limited capacity to collect, monitor, and evaluate complex management information prevents it from clearly distinguishing the positive and negative effects of implemented policy changes:

- » Contentious policy prescriptions are difficult to properly test.
- » This knowledge management problem outpaces the DoD's capacity to respond to the problem.
- » Policy recommendations are made without data to support assertions.

Appendix E – Section 219

A Closer Look at Section 219 Funding

Funding via the Section 219 authority has supported 39 percent of the total (combined with major MILCON) laboratory Infrastructure investments between FY13-15.

Army: Invested \$117.4 million in infrastructure from FY13-15 through Section 219. 67 percent of the Army's total combined infrastructure investments were funded through section 219 in FY13-15. In FY15, the Army invested in 64 infrastructure projects totaling \$45.2 million. These projects ranged in cost from \$3,000 to \$4.2 million. They supported a wide range of needs—from handicap access to laboratory buildings to critical upgrades to the Precision Armaments Laboratory.

Air Force: Invested \$20 million in infrastructure from FY13-15 through Section 219. The Air Force did not receive any major MILCON funding for laboratory infrastructure across the three years, but were able to invest in infrastructure through section 219. In FY15, the Air Force invested \$9.4 million in infrastructure projects, most notably the Maui Innovative Situational Awareness (MISA) Lab at \$3.8 million. Sixteen infrastructure projects were planned or underway in FY16 totaling \$28.4 million, a marked increase over previous years. The Air Force has recently increased the use of Section 219 funds to improve infrastructure, particularly at the AFRL. The Air Force has \$28 million planned for infrastructure in FY16.

Navy: Invested \$19 million for infrastructure from FY13-15 through Section 219. Although the Navy received a relatively significant portion of their combined infrastructure investment from major MILCON, they still leveraged Section 219 funding for nearly 10 percent of their total investment. In FY15, Navy infrastructure revitalization and recapitalization accounted for \$7 million.

Appendix F – Entrepreneurial Programs

Entrepreneurial Programs: ARL

The ARL – Entrepreneurial Separation Program (ESP) and Sabbatical Program are two separate programs at the ARL.

The ESP was established December 2014 and, at the time of this report, two people were enrolled in the program. The ESP requires employees to separate from federal service with the caveat of being able to return Government service with priority consideration.

Sabbaticals are an employment opportunity that provides career-enriching education or research experiences and increased participant's contribution to the goals and mission of the Lab. Employees on sabbatical assignments do not have to separate and will be paid their Government salary and benefits. At the time of this report, the ARL has two people on sabbatical, and a total of five people for the 2015-2016 year.

The ARL has not initiated any effort to implement the NDAA authority, as they are focusing on reviewing the legislation and comparing their existing program to the Air Force program.

Entrepreneurial Programs: AFRL

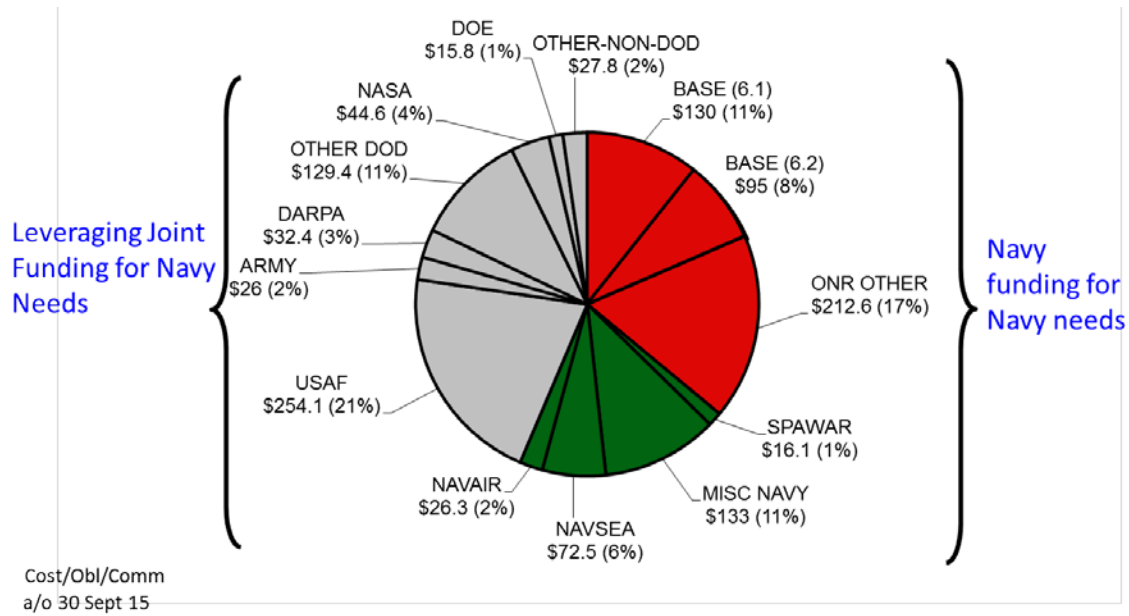
The AFRL Entrepreneurial Opportunities Program (EOP) was approved by the AFRL Executive Director in August 2015. While a dozen or so potential candidates expressed varied levels of interest in AFRL's EOP, no applications had been approved at the time of this report. The AFRL expects to imminently approve several requests with the program enhancements that will become effected shortly.

The AFRL established the EOP to support the technology transfer mission by providing entrepreneurialism as a viable mechanism for maturing promising AFRL technologies into commercial products that benefit national security and U.S. economic prosperity. The EOP is to be used by AFRL S&Es for several purposes:

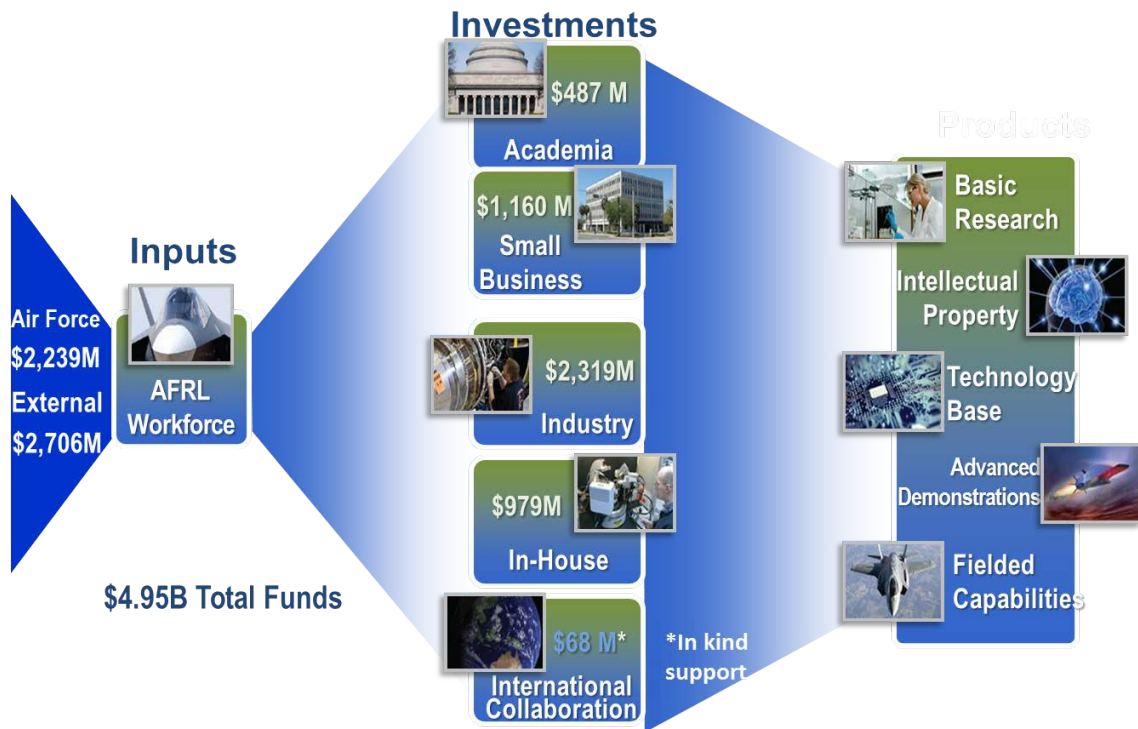
- » The S&E is seeking a license from the AFRL for AFRL-developed intellectual property to start his or her own technology-based business.
- » The S&E is seeking to join an existing technology-based business that is an AFRL licensee in order to provide technical support.
- » The S&E is seeking to start or expand a technology-based business using technical expertise developed at AFRL.

Appendix G – NRL Sponsors

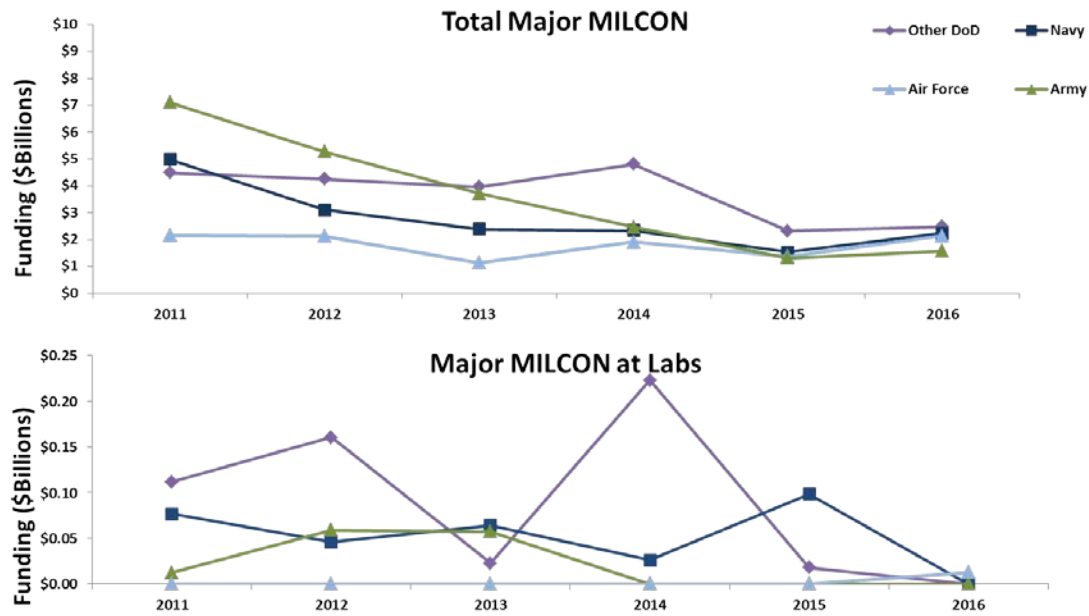
Total \$1,215.6 Million-FY15 Costs



Appendix H – AFRL S&T Business Model



Appendix I – Major MILCON



Appendix J – FFRDCs and UARCs

Federally Funded Research and Development Center:

- » A privately-operated entity established by an executive department or branch entity to meet long-term research needs. They:
 - operate in the public’s interest with objectivity and independence without conflict of interest;
 - have a comprehensive knowledge of sponsor needs, such as mission, core technical competencies or capabilities, and institutional memory allowing for quick response times; and
 - are allocated funding and staff year ceilings each FY by Congress.



University Affiliated Research Center:

- » A university-operated research organization established by an executive department or branch entity to provide long-term research and development capabilities. They:
 - are very similar to an FFRDC but receive no guaranteed staff hours or annual funding from Congress; and
 - should compete for all work but are eligible to pursue engagements with other Government entities in addition to their primary sponsor.



Appendix K – Private Industry Laboratory Models

- » The primary responsibility is to the shareholder.
 - Shareholders determine leadership, which sets strategic direction and priorities for the organization.
- » Advanced R&D focuses on creating value by inventing new products or solving business problems.
- » Typically a mixture of directed and self-initiated research, some funded directly by internal or external customers.
- » Investments are prioritized based on a rigorous risk-reward analysis.
 - In order to maximize return on investment, risks are balanced against potential reward when project funding decisions are made.
- » Portfolio size and composition driven by market forces.
- » Market demand tends to drive product development and offerings.
- » This may or may not lead to industry focused efforts on national security R&D.



Appendix L – United Kingdom Laboratory Model

QinetiQ:

- » A British multinational defense technology company.
- » Formerly the Defence Evaluation and Research Agency (DERA).
- » In 2001, a significant portion of DERA was privatized and renamed QinetiQ.
 - The remainder of DERA became DSTL.
- » The Ministry of Defence (MoD) keeps a “special share” (56 percent ownership) in QinetiQ but avoids conflict of interest issues through special safeguards.



Defence Science and Technology Laboratory:

- » Established to carry out S&T considered inherently governmental.
- » Purpose is to maximize the impact of defense S&T.
- » 93 percent of budget is funded through the MoD while the rest is funded by other government departments and commercial sources.
- » Conducts a broad range of research often with the support and partnership of industry and academia in areas including:
 - High-level analysis supporting policy and procurement decisions.
 - Technical research (e.g. biomedical science).
 - Operational work (e.g. forensic analysis of explosives).
- » Responsible for the MoD’s non-nuclear research centers in 16 different topic areas.



Appendix M – Australia Laboratory Model

Defence Science and Technology Organisation:

- » Government Agency:
 - second largest R&D organization funded by the Australian government behind CSIRO, an economic and social focused R&D organization; and
 - has an annual budget of approximately \$440 million and employs over 2500 staff, predominantly scientists, engineers, IT specialists, and technicians.
- » Coordinates R&D for Australia's national security:
 - examines future technologies for defense and national security applications;
 - develops new defense capabilities and advises on the purchase and smart use of defense equipment; and
 - provides scientific and technical support and enhancements to current defense operations.
- » Government-Industry Partnerships:
 - works closely with industry and universities to enhance defense capability; and
 - manages the Capability and Technology Demonstrator (CTD) program, which provides funding for Australian businesses to demonstrate new technologies or the novel use of technology for defense applications.



Australian Government

Department of Defence

**Defence Science and
Technology Group**

Appendix N – Acronyms and Abbreviated Terms

ACH	Advanced Combat Helmet
AFB	Air Force Base
AFLCMC	Air Force Life Cycle Management Center
AFRL	Air Force Research Laboratory
AFSOC	Air Force Special Operations Command
ARAP	Army Readiness Assessment Program
ARL	Army Research Laboratory
ASA	Assistant Secretary of the Army
ASD(R&E)	Assistant Secretary of Defense for Research and Engineering
ASN(FM&C)	Assistant Secretary of the Navy for Financial Management and Comptroller
ASN(RDA)	Assistant Secretary of the Navy for Research, Development, and Acquisition
BATMAN	Battlefield Air Targeting Man-Aided Knowledge
BBP	Better Buying Program
BLS	Blast Load Simulator
BRAC	Base Realignment and Closure
C4I	command, control, communications, computers, and intelligence
CAPE	Cost Assessment and Program Evaluation
CDD	capability development document
CICADA	Close-in Covert Autonomous Disposable Aircraft
CINCPAC	Commander in Chief, Pacific Fleet
CNO	Chief of Naval Operations
COI	Community of Interest
COTS	commercial off-the-shelf
CREB	Center for Research in Extreme Batteries
CTD	Capability and Technology Demonstration
DARPA	Defense Advanced Research Projects Agency
DERA	Defence Evaluation and Research Agency
DIB	Defense Industrial Base
DIUx	Defense Innovation Unit Experimental
DoD	Department of Defense
DOE	Department of Energy
DON/AA	Department of the Navy Assistant for Administration
DSB	Defense Science Board
DSTO	Defence Science and Technology Organisation
DSTL	Defense Science and Technology Laboratory
ECH	Enhanced Combat Helmet

ELG	Executive Level Group
ELINT	electronic intelligence
EM	electromagnetic
EO	electro-optical
EOP	Entrepreneurial Opportunities Program
ERDC	Engineer Research and Development Center
ESP	Entrepreneurial Separation Program
EUL	Enhanced Use Lease
EW	electronic weapon
ExCom	Executive Committee
FFRDC	Federally Funded Research and Development Center
FMB	Financial Management Budget
FY	fiscal year
GCAS	Ground Collision Avoidance System
GLOC	G-force Induced Loss of Consciousness
GOCO	government-owned, contractor-operated
GPS	global positioning system
GRAB I	Galactic Radiation and Background I
HAIL	Human Alerting and Interruption Logistics
HQ	headquarters
HVAC/DDC	heating, ventilating, and air conditioning/digital data control
ICT	Institute for Creative Technologies
IED	improvised explosive device
IT	information technology
KPP	Key Performance Parameters
LASCO	Large Angle Spectrometric Coronagraph
LaWS	Laser Weapon System
LCS	littoral combat ship
LDUUV	large displacement unmanned underwater vehicle
MILCON	military construction
MISA	Maui Innovative Situational Awareness
MOA	memorandum of agreement
MoD	Ministry of Defence
NASA	National Aeronautics and Space Administration

NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Command
NAVFAC HQ	NAVFAC Headquarters
NAVSEA	Naval Sea Systems Command
NDA	National Defense Authorization Act
NDU	National Defense University
NICAP	Naval Infrastructure Capabilities Assessment
NIST	National Institute of Standards of Technology
NRAC	Naval Research Advisory Committee
NRL	Navy Research Laboratory
NSPS	National Security Personnel System
NSRO	Network Science Research Laboratory
NSWC	Naval Surface Warfare Center
NY-BEST	New York Battery and Energy Storage Technology Consortium
NWCDD	Naval Surface Warfare Center - Dahlgren Division
ODNI	Office of the Director of National Intelligence
ONR	Office of Naval Research
OPM	Office of Personnel Management
OSD	Office of the Secretary of Defense
OTA	other transactional authority
OUSD(AT&L)	Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics
OUSD(R&E)	Office of the Under Secretary of Defense for Research and Engineering
POM	Project Objective Memorandum
R&D	research and development
RDT&E	research, development, test, and evaluation
RFP	Request for Proposal
S&E	science and engineering
S&T	science and technology
SECCHI	Sun Earth Connection Coronal and Heliospheric Investigation
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SEMASC	Specialty Electronic Materials and Sensors Cleanroom
SMART	Science, Mathematics, and Research for Transformation
SOLRAD I	Solar Radiation I
SPAWAR	Space and Naval Warfare Systems Command
SRD	source requirement document
SSFL	solid-state fiber laser
SSTM	Senior Science and Technology Manager

STEM	science, technology, engineering, and mathematics
STRL	Science and Technology Reinvention Laboratory
TSRL	Tri-Service Research Laboratory
TTP	Technology Transition Plan
UARC	University Affiliated Research Center
UAV	unmanned aerial vehicle
UHMWPE	ultrahigh molecular weight polyethylene
USAF	United States Air Force
USC	University of Southern California
USD(AT&L)	Under Secretary of Defense for Acquisition, Logistics, and Technology
USD(P&R)	Under Secretary of Defense for Personnel and Readiness
UT	University of Texas
UUV	unmanned underwater vehicle
VERA	voluntary early retirement
VSIP	voluntary separation incentive payment
WCF	Working Capital Fund
WFO	work for others
WMD	weapons of mass destruction