



X-51A Waverider, powered by Pratt Whitney Rocketdyne SJY61 scramjet engine, prepares for hypersonic flight by riding its own shockwave, accelerating to nearly Mach 6 (U.S. Air Force graphic)

Adapting for Victory

DOD Laboratories for the 21st Century

By William T. Cooley, David J. Hahn, and John A. George

The United States must regain the element of surprise and field new technologies at the pace of modern industry. Government agencies must shift from an archaic R&D process to an approach that rewards rapid fielding and risk-taking.

—NATIONAL SECURITY STRATEGY OF THE UNITED STATES OF AMERICA

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In an era of renewed Great Power competition, the technological advantage of the U.S. military—long the cornerstone of our military assurance and hence world security—is threatened. Strategic competitors, chief among them the People’s Republic of China and the Russian Feder-

ation, are now approaching parity in many areas. Their stated intent is to reach full parity, and then achieve technological dominance themselves, in an accelerated timeframe. The consequences of that to the United States and the rest of the world are unacceptable.

The U.S. military excels from under-sea to cyber to space, but as the National Defense Strategy reminds us, “America’s military has no preordained right to victory on the battlefield.”¹ In this challenging moment, the process by which the Department of Defense (DOD) and military Services conduct research and develop new capabilities for our warfighters must be reviewed, renewed, and reimagined. We must maintain our edge and also achieve advantage in emerging fields such as directed energy, artificial intelligence, hypersonics, autonomy, quantum capability, synthetic biology, and technologies of the future that have not yet been imagined. We, as commanders of the science and technology (S&T) laboratories of the Army, Navy, and Air Force, are working together to ensure the continued U.S. advantage in the race for military technological superiority.

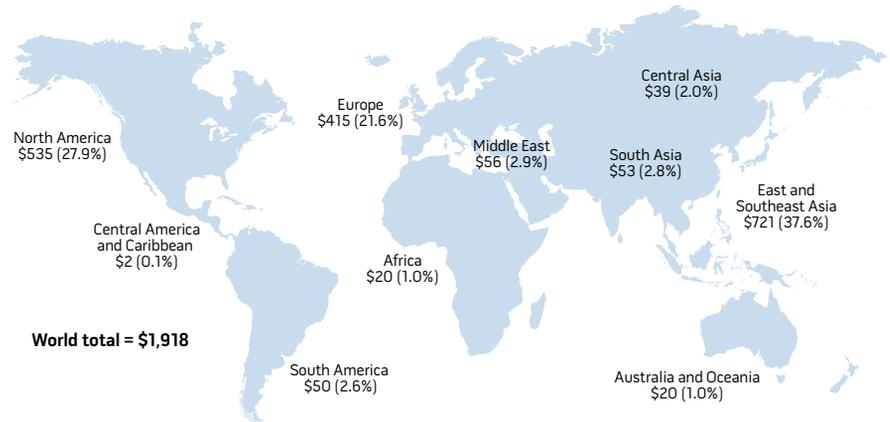
Call to Action for a New Era

Our established processes for basic and applied research worked well during the post-World War II era. DOD laboratories, in partnership with the U.S. defense industrial base, met operator requirements via S&T and research and development (R&D) programs. U.S. academia, backed by generous Defense funding, helped identify approaches to solve new problems.

However, this domestic- and government-centric approach to basic and applied research, developed and refined during the Cold War, cannot remain in stasis in today’s strategic environment. The global technology landscape has changed. The world is more technologically “flat” than it once was. As shown in the figure, the United States accounts for only a fraction of today’s global R&D expenditures. The U.S. Government invests less in R&D than the private sector, and the leading edge of many emerging fields is being advanced by privately funded large technology companies and nimble startups that have little or no connection to defense R&D. With modern information systems, knowledge and technology are easier and cheaper for adversaries to obtain and quickly weaponize.

Figure. Global R&D Expenditures, by Region: 2015

Billions of U.S. PPP dollars



Note(s): Foreign currencies are converted to dollars through PPPs. Some country data are estimated. Countries are grouped according to the regions described in *The World Factbook*, available at <www.cia.gov/library/publications/resources/the-world-factbook/index.html>.

PPP = purchasing power parity.

Source: National Science Board, Science and Engineering Indicators 2018.

Driven by consumer demands and competition, many companies develop and implement new technologies at impressive speeds that are far faster than our existing government acquisition processes. Companies know they would have to slow down and fight through cumbersome Federal acquisition regulations to do business with the military. In a 2016 report, the Center for a New American Security noted that the “decreased demand, lower profitability, and high barriers to entry have made the defense market less attractive than at any time in modern history.”²

To maintain superiority and meet the guidance of the National Defense Strategy, there is urgent need for dramatic change and acceleration in how DOD does the hard business of S&T and R&D. To be successful in today’s flat tech-access world, DOD must adapt its R&D model for greater speed and agility *and* a greater capacity to leverage expertise from tech sectors unaccustomed to collaborating with the U.S. Government. This call to action has been evident in recent strategic products and actions including the National Defense Strategy, the Naval Research and Development Framework, the Air Force Science and Technology Strategy, and the establishment of Army Futures Command.

This is not the first time the Nation has faced an urgent call to adapt. As the

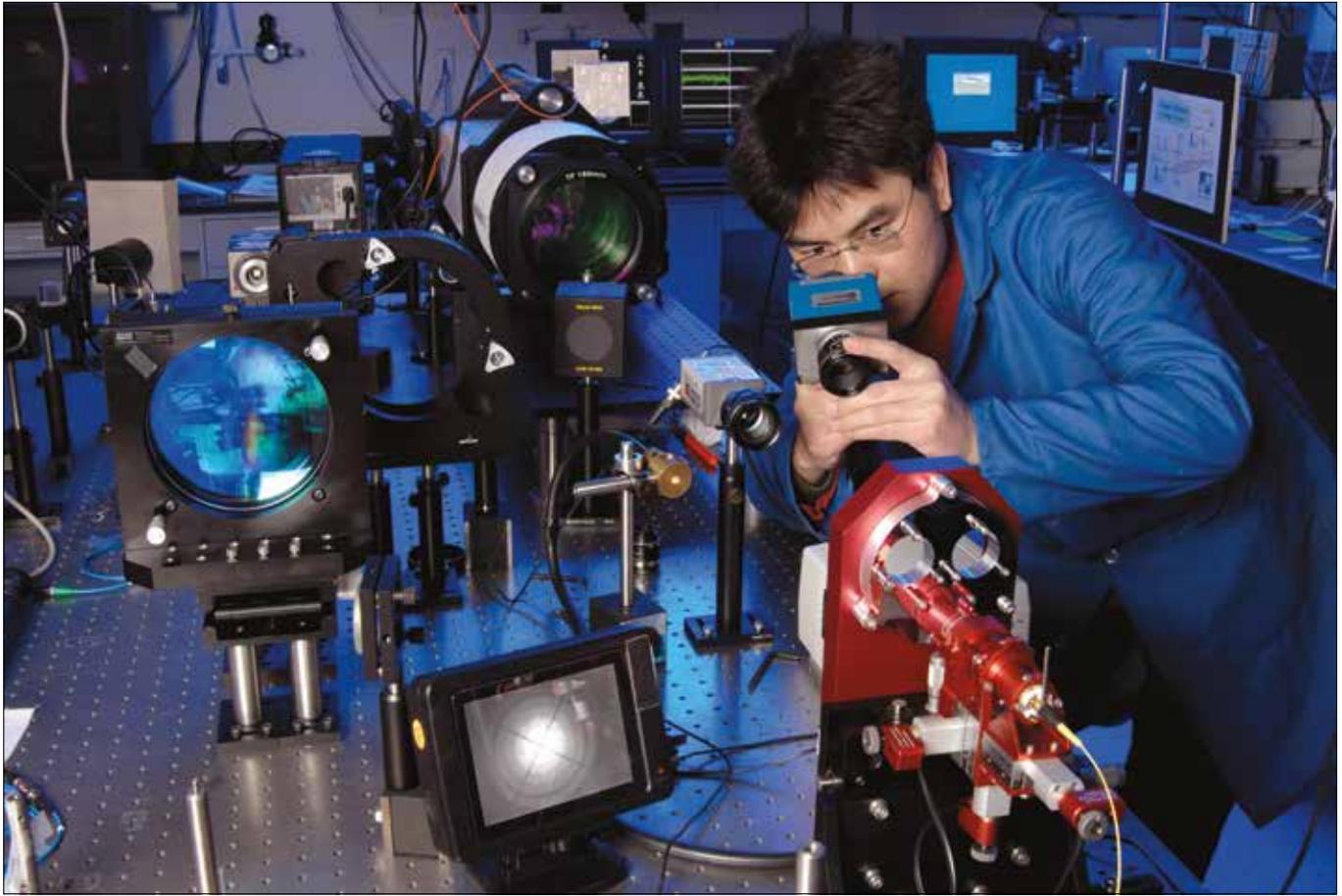
1947 Scientific Research Board reported to President Harry Truman, the “security of the United States depends today, as never before, upon the rapid extension of scientific knowledge. So important, in fact, has this extension become to our country that it may reasonably be said to be a major factor in national survival.”³ Our current lab structure came about in part due to that realization and helped provide decades of technological advantage. We answered the call before, and we are answering it again.

The Agenda for Change Within the Labs

It is of the utmost importance to our national security that the Navy prosecute a vigorous and well-rounded program of research and development. To fail to do so in time of peace will surely result in this country entering another war with obsolete weapons and machines of warfare. And the tempo of modern war has reached the point where this nation will probably never again have an opportunity to arm itself successfully after the start of hostilities.

—James Forrestal, Secretary of the Navy, 1944–1947

As commanders of DOD laboratories, we know that business as usual will not sustain U.S. technological advantage. In



Army Research Laboratory's electronics program seeks to generate knowledge of electromagnetic, photonic, and acoustic devices, systems, and phenomena to provide technological superiority to Army's future force (Army Research Laboratory)

fact, business as usual will lose the fight. We must change how we operate in order to maintain our technological lead. We must retool how we do the hard business of discovering, developing, and fielding new capabilities, at sufficient scale, for our warfighters. And we must do all of this quickly. The bottom line is that we must radically adapt our laboratories to today's S&T environment, embracing risk and eschewing the status quo. This is America's national challenge at this unique moment in history, as urgent as any we have faced before.

We seek to adapt in the ways that need to change, while retaining and refreshing the unique and valuable aspects of the DOD lab system that have helped our defense S&T excel. The United States has been able to defeat some of the most aggressive regimes in the world in large part due to technologies made possible by a vibrant relationship between academia, industry, and the military,

using Federal sponsorship and funding of research through DOD labs. It is a unique partnership that has served freedom well. DOD labs are part of a larger ecosystem of discovery, innovation, and collaboration—one in which investment is focused on warfighter needs without regard to the short- and long-term profits prioritized by private industry.

DOD labs, and the extramural research programs they oversee, execute the basic scientific research that helps us understand fundamental aspects of military-relevant scientific phenomena and gain the insights necessary to develop future warfighting applications. As just one example, today's laser weapons systems would not have been possible without sustained, military lab-supported basic research by Charles H. Townes and others into microwave amplification by stimulated emission of radiation, or masers, starting in the 1950s. In short, if the labs do not perform this function, no

one will. DOD labs then guide the results of basic research into more advanced R&D that applies the basic science in new devices, components, and even full-scale prototypes—ideally transitioning into future acquisition programs.

These basic functions are enduring, but we have identified many specific areas where major changes are needed in order to carry them out effectively in the technology environment of the 21st century. Some of the most critical areas are contracting and partnering, financial agility, and workforce development. While these are not always recognized as vital for success on the battlefield, they play crucial roles in the military's ultimate success or failure in developing technology for our warfighters.

For too long, DOD labs have struggled to get contracts issued in a timely manner, due to decades of steadily increasing red tape. The result is research that is often old where it was once new.

And even worse, brilliant, patriotic researchers can decide that the sluggish pace of getting contracts decided and funds delivered—coupled with a constant need to fill out forms—is not worth it and begin looking elsewhere for a more efficient workplace.

As one example, a 2018 faculty workload survey conducted by the Federal Demonstration Partnership revealed that principal investigators—that is, scientists and engineers looking for breakthroughs that will help us achieve mission success—estimate they spend 44 percent of their research time during Federally funded projects meeting administrative requirements, instead of doing actual research.⁴ This is a sobering figure and a disservice to our Servicemembers who are depending on unimpeded delivery of cutting-edge tech to do their job and defend the Nation.

The underlying reason for DOD labs' success is our greatest asset: our people. However, worries and hurdles regarding workforce development have grown rather than diminished. As the demand for science, technology, engineering, and math college graduates increases faster than the supply, recruiting top-notch researchers dedicated to national defense becomes more challenging. This is particularly worrisome as we see significant numbers of our researchers and program officers beginning to retire. To retain a cutting-edge workforce, we must continue to build more flexible and modern employment models, find innovative ways to compete with private industry salaries, and ensure workforce diversity in all its dimensions.

Behind all these ideas is the reality that researchers can face daily frustrations and disincentives when working for DOD labs. Poorly functioning information technology (IT) systems, excessive training requirements, and other bureaucratic hurdles often limit the time scientists and engineers can dedicate to actual research each day. Exit interviews with DOD researchers leaving military laboratories indicate many of these researchers are not leaving DOD in search of higher salaries or more meaningful purpose—rather, they are seeking positions where their

time will be optimized. Recent initiatives to reduce online training requirements are one way to help solve this issue. While increasing the efficiency and lowering the burden of processes may not seem critical at first, innovations in these areas are important to developing the talent and technologies we need to prevail in future conflicts.

New Cooperation and New Reforms

We should remember that it was the technical superiority of our forces that provided the basis for our strategic advantage in the years following World War II. For that reason, we strongly advocate the continuation of an intensive technical effort to [e]nsure that we preserve the qualitative edge in weapon systems.

—General Curtis LeMay, Chief of Staff of the Air Force, 1961–1965

Faced with the self-evident need to adapt, and encouraged to drive change from the highest levels of leadership, DOD lab commanders have been meeting quarterly since November 2017 with the goal of synchronizing efforts, gaining efficiencies, and enhancing collaboration across Service labs. We have focused on defense technology priorities and have begun to align business practices that will increase information transparency.

These proactive efforts have yielded early results that are making a difference. Three examples highlight the ways DOD labs are working together to develop joint solutions, share best practices, and accelerate our shared progress. These include our work in establishing new and efficient enterprise business systems, our initiatives in R&D management data analytics, and our design and implementation of Open Campus initiatives for partnering and workforce development.

Enterprise Business Systems. A tri-Service collaboration team, led by the Air Force Research Laboratory, is putting IT tools, people, and processes in place to enable the labs to operate as highly efficient, transparent organizations—fueled by the ability to make

data-driven management decisions and execute integrated business functions. For example, an intelligent Business Process Management platform and shared development environment are being implemented, enabling a team to develop multiple integrated applications. These changes will allow real-time information on contracts, finances, and other topics—collected automatically through the conduct of daily work, eliminating burdensome taskings to collect information. They will also provide up-to-date, information-rich pictures for decision-makers, allowing business decisions to be made more quickly and effectively. Lessons learned from testing at the Air Force Research Laboratory will be shared to benefit the other Services.

R&D Management Data Analytics. Early in the history of quarterly joint meetings, the DOD lab commanders established a data analytics working group, with the objective of establishing cross-Service sharing of S&T and R&D data to improve collaboration. One of the chief challenges identified by the working group was the variation of data collected and modeled in the Services' financial systems. To address this, the group focused on defining a data catalog of the minimum viable product (MVP), containing metadata for all grants, contracts, and funding documents to external institutions. This MVP data catalog supports analytics to help identify common research interests and institutions, performer networks, and funding levels. When combined with external data sets, the MVP helps identify emerging technology areas, rising stars, and core research institutes. The working group is currently deploying this capability to a government cloud environment, allowing for collaborative data-driven decision-making across the three Services.

Open Campus Initiatives. These efforts were spearheaded by the Army Research Laboratory several years ago to pilot new approaches to building a broader science and technology ecosystem—thus enabling DOD laboratory scientists and engineers to work collaboratively and side by side with visiting scientists and other partners in

lab facilities and likewise allowing DOD researchers to work at collaborators' institutions. These also involve creation of flexible career path options that allow easier transitions between government, academia, and industry. As a result of collaboration between the Services, lessons learned are being shared that are helping other DOD labs implement the most successful practices that have emerged from the Army's experiences and develop new ideas to expand the concepts even further.

These are only the start. Many other activities are under way across our labs that are breaking new ground. For instance, DOD and the individual Services are rapidly establishing innovation centers across the Nation—physical locations meant to bring together leading minds to facilitate collaboration and accelerate products. From the Defense Innovation Unit to the Air Force's AFWERX to the expansion of the Army's Open Campus to the Navy's new NavalX Agility Office featuring regional technology hubs called Tech Bridges, we are paving new roads (sometimes literally) to connect the warfighter with innovators. These centers tap into commercial technology and innovation, following best-practice business models that reduce bureaucracy. They have storefronts in many major cities to make connections with industry. They can also facilitate partnerships, focus projects on warfighter needs, and ensure technology transitions.

Congress has also given DOD labs special authorities to increase speed and agility for contracting and partnership agreements and the associated financing. The labs have been granted special authorities to recruit and hire the best scientists and engineers available, using hiring processes outside the regular government hiring pace. Each Service brings its own experiences implementing these authorities that other labs can leverage, enabling the joint team to progress together.

All these changes have begun to enable faster delivery of more lethal capabilities across the Service labs. Additional initiatives are being pursued within individual Services, with an eye toward

sharing their benefits and results with our peer labs in the other Services.

First, the Army's modernization strategy is focused on one goal: to make Soldiers and units far more lethal and effective than any adversary. The establishment of the Army Futures Command (AFC) is the largest organizational change the Service has undertaken in more than 40 years. AFC is charged with leading a continuous transformation in order to provide future warfighters with the concepts, capabilities, and organizational structures they need to win on the battlefield. The elements of the Army's Future Force modernization enterprise have moved from separate commands into AFC to achieve the unity of command and effort that leaders believe are essential to meeting these global challenges.

Under AFC, the Combat Capabilities Development Command (CCDC), formerly the U.S. Army Research, Development, and Engineering Command, is in the second year of an internal campaign of reform, realignment, and process improvement. As part of AFC, CCDC has positioned itself to integrate more effectively with the operational Army and to mature relationships with AFC cross-functional teams, which have been given the mandate to improve delivery of the Army's six modernization priorities: long-range precision fires, next-generation combat vehicles, air and missile defense, Soldier lethality, network, and future vertical lift.

The Army also analyzed the process to pinpoint bottlenecks and identify workarounds. In an article released in 2018, the Service noted that "successful transitions begin early during science and technology development with the establishment of strong working relationships between technologists within the research laboratories and program executive officers and program managers."⁵ Additionally, there is an opportunity for the DOD R&D community to enable the development of smarter requirements by increasing the use of prototyping and experimentation venues and incorporating warfighter feedback, while also leveraging innovative research from our industry and academic partners.

Second, the Naval Research Enterprise (NRE) has significantly reorganized to streamline and accelerate the way it discovers, develops, and delivers new capabilities for Marines and Sailors—including using new congressional authority to eliminate the need to recompete contracts for development of initial prototypes within already existing, approved research. This is only common sense because it is difficult to imagine why any organization would have to recompetete to do a prototype within the timespan of its own already approved research program. After these and other changes, the Chief of Naval Research announced in 2018 dramatically shortened timelines for critical Future Naval Capabilities (FNCs)—high-priority, fast-tracked research—to reach programs of record: It is now 3 years or less, vice the previous standard of 5 years, from "we need this" to "here you go."

Other naval efforts bearing fruit include naming an outside-the-box-thinker senior executive as the new "naval accelerator"—a senior leader with deep familiarity of successful private industry practices—charged with finding new ways to utilize private industry practices within the Service. The NRE is optimizing business operations and personnel management practices, facilitating "bridge award" authority to ensure projects near the end of a term can be brought to completion, and even trying to solve something as mundane as increasing the limits on purchase cards—long a sore spot for performers whose work comes to a screeching halt due to an inability to legally purchase a small piece of equipment without significant delay and paperwork. (This one change alone has facilitated the execution of hundreds of transactions at the Naval Research Laboratory, allowing expedited purchase of critical scientific and engineering materials and saving an estimated 1,000 days of processing time.)

These and other steps have enabled the NRE to move at speed to deliver lethal, sustainable capability. In fiscal year 2018, the NRE accelerated 30 FNCs to the fleet, while realistically deciding 21 others were not ready and taking them out of the accelerated pipeline. In fiscal



Dr. Courtney Webster makes adjustments to Warrior Web physical augmentation suit from Harvard's Wyss Institute in Boston, Massachusetts (Army Research Laboratory/David McNally)

year 2019, just a few of the new FNC capabilities reaching our Marines and Sailors included rocket imaging seekers, avionic trainers, logistics support tools, and detection and classification algorithms. And in fiscal year 2020, 19 new FNCs include new capabilities in sonar systems, electromagnetic warfare, fleet training technologies, diver safety, unmanned systems, and more.

Third, the Air Force recently completed an 18-month study with higher education and industry that resulted in the Science and Technology 2030 Strategy. The Air Force Research Laboratory (AFRL), Air Force Warfighting Integration Capability (AFWIC), and the Office of the Assistant Secretary of the Air Force for Acquisition, Technology, and Logistics (SAF/AQ) are using the strategy to develop and deliver on the five transformational strategic capabilities outlined in 2030, reform the way S&T are led and managed, and

deepen and expand the scientific and technical enterprise. To affect these changes, and ultimately drive competition to address interdisciplinary joint force challenges, AFRL is launching multiple lines of effort.

The new AFRL Transformational Capability Office (TCO) will provide enterprise management of advanced technology development programs, ensuring integration of required competencies from the AFRL Technology Directorates. The TCO will also manage the Air Force's Vanguard programs, another core element of the S&T 2030 Strategy. Vanguards are short duration, highly focused programs that drive forward innovative capabilities to advance emerging weapons systems and warfighting concepts through demonstration, experimentation, and prototyping. AFRL is working closely with AFWIC, SAF/AQ, and major commands through recurring summits and workshops to ensure

technology development programs, including Vanguards, fulfill warfighter requirements. AFRL is embedding highly qualified scientist and engineer liaisons on major command staffs to synchronize with operational requirements and ensure support for successful technology transition.

Additionally, AFRL is using Modeling Simulation and Analysis (MS&A) tools to predict the relative impact of potential technical capabilities on future Air Force operations. MS&A offers insights into technical concepts before making large investments. Coupled with wargaming exercises, these approaches bring the operational community into the research process, allowing them to influence the design and employment concepts to increase mission compatibility of the products sooner. We expect these approaches to reduce timelines and costs.

AFRL recognizes the importance of leveraging the research investments of

external organizations. Consequently, we are emphasizing strong partnerships with other government agencies, international partners, academia, and the commercial sector with close attention to nontraditional players in the DOD ecosystem. This includes tech startups, venture capitalist firms, and small businesses. To that end, AFRL will reinforce the lead, leverage, watch (LLW) model for managing technology development. With LLW, AFRL will identify those areas with specific Air Force applications where military lab leadership is appropriate (lead) vice those being pursued by academia, industry, and other agencies that have a primarily commercial purpose but with potential for Air Force applications (leverage). For promising technologies with unclear military utility, AFRL will closely monitor their progress (watch).

Finally, AFRL is adapting recruiting and management practices to get in lock step with the demands of a 21st-century workforce. New recruiting strategies and agile workplace practices will help the lab acquire and retain top talent from across the Nation. This is especially important in high-demand technology sectors, such as artificial intelligence and data analytics, where talent is difficult to retain due to competition from the private sector.

Conclusion: A Focus on Enabling the Joint Warfighter

Progress in scientific research and development is an indispensable condition to the future welfare and security of the nation. . . . Science in this war has worked through thousands of men and women who labored selflessly and, for the most part, anonymously in the laboratories, pilot plants and proving grounds of the nation. Through them, science, always pushing forward the frontiers of knowledge, forged the new weapons that shortened the war.

—President Harry Truman, *Special Message to Congress, 1945*

Then Secretary of the Air Force, the Honorable Heather Wilson, pointed out that the “[S]ervices . . . are on the cusp

of becoming integrated . . . not just interdependent, not just joint, but integrated in our operations.” Because if we could do that—if we can “gather information faster, decide faster, and act faster on that information”—then we are going “to prevail in 21st-century conflict.”⁶ We are on the cusp of being able to think and move in that direction. The DOD lab commanders continue to expand collaboration and alignment between the Services. This partnership brings the joint force closer to the necessary integrated operations DOD needs going forward.

All this collaboration is for naught unless we can get technology into the hands of our warfighters. The growing sophistication of our potential adversaries against the backdrop of information-age warfare requires seamless integration and execution. In order to remain the world’s most lethal and capable fighting force, we must be able to innovate and operate faster and more effectively than our adversaries. We must continue to work toward the big technology breakthroughs that not only keep future fights unfair and provide overmatch but also change the equation altogether.

Part of dominance is being so strong that adversaries do not dare to act with bad intent. We can and must maintain that deterrent capability.

The DOD laboratories recognize the need for change, and we are acting now. We are strengthening our workforce and business practices to keep up with and indeed set the standard for best practices. Our teams are keen to build partnerships with academia, industry, governmental agencies, and international partners to ensure technological superiority in the 21st century.

We do not have all the answers yet. However, we believe a unified strategy with fully committed agents can guide DOD toward success. The proposals outlined here are not simply theoretical. We are acting on them and making them reality, and we invite others to join us, advise us, and partner with us. We need to move forward smartly, and we look to senior DOD leaders and Congress to help us remove roadblocks.

The Nation’s military labs are but one player in the overall DOD system of delivering capability to ensure victory. However, we realize the serious responsibility we have: Future military power starts here. The United States, and the DOD labs, have an advantage: We are part of multiple thriving partnerships of the best minds in the world. We can support research that is determined not by the stock market but by the marketplace of ideas. DOD labs are the only place this can occur. It is a responsibility, a challenge, and an opportunity of the highest order.

We call upon key partners within our own Services—as well as the Office of the Secretary of Defense, elected officials, other governmental agencies, large industry and small business, academia, Federally Funded Research and Development Centers, and more—to join us in this critical mission. JFQ

Notes

¹ *Summary of the National Defense Strategy of the United States of America: Sharpening the American Military’s Competitive Edge* (Washington, DC: Department of Defense, 2018), 1, available at <<https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>>.

² Ben FitzGerald, Alexandra Sander, and Jacqueline Parziale, *Future Foundry: A New Strategic Approach to Military-Technical Advantage* (Washington, DC: Center for a New American Security, 2016), 4, available at <www.cnas.org/publications/reports/future-foundry>.

³ Quoted in *A Report to the Secretary of the Navy on Basic Research in the Navy*, vol. 1 (Washington, DC: Naval Research Advisory Committee, 1959), 1.

⁴ “2018 FDP Faculty Workload Survey: Plan and Preliminary Results,” Federal Demonstration Partnership, Washington, DC, 2018, available at <<http://thefdp.org/default/assets/File/Presentations/FDP%20FWS%20Prelim%20Summary%20090618%20post.pdf>>.

⁵ Julie I. Locker, “Army Bridges Gap Between Concept and Acquisition for Successful Technology Transitions,” *Army.mil*, February 26, 2018, available at <www.army.mil/article/201106/army_bridges_gap_between_concept_and_acquisition_for_successful_technology_transitions>.

⁶ Steve Hirsch, “U.S. Services on ‘Cusp’ of Integration, Wilson Says,” *Air Force Magazine*, March 12, 2018, available at <<http://airforcemag.com/Features/Pages/2018/March%202018/US-Services-on-Cusp-of-Integration-Wilson-Says.aspx>>.