



Data Brief

A Quantitative Assessment of Department of Defense S&T Publication Collaborations

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Executive Summary

While the effects of the Department of Defense's broad investments in research and development go far beyond what is publicly disclosed, authors affiliated with the DOD do publish papers about their research. These papers reflect a small portion of the DOD's engagement efforts across an enormous research ecosystem, but they nonetheless offer some insight into the patterns of research collaboration by the DOD. By analyzing more than 100,000 papers authored by researchers affiliated with the DOD* in the OpenAlex database, we find:

- Of 100,158 DOD-affiliated papers that we manually reviewed for specific entity affiliation, approximately 86% list an author from a DOD organization (such as the U.S. Army, Naval, or Air Force Research Laboratory), 12% include a DOD-affiliated federally funded research and development center or university affiliated research center (FFRDC/UARC), and 2% have both a DOD and a DOD FFRDC/UARC affiliated author.[†]
- Approximately 31% of the papers list a co-author from an institution not affiliated with the DOD. Of those, the large majority come from academia (83%), while much smaller proportions are from non-DOD government research labs, private companies, non-profit institutions, and international organizations.
- The top 10 publishing DOD-affiliated institutions are also the organizations that oversee and manage the majority of basic research funding within the military services (Army, Navy, Air Force), though military medical institutions figure prominently and two DOD educational institutions also make the list, alongside one UARC.

* We include researchers from DOD organizations and research laboratories, as well as researchers at official DOD federally funded research and development centers and university affiliated research centers (FFRDCs/UARCs).

[†] Our search returned 136,008 papers, but there were numerous instances where an author institution was listed in multiple ways (i.e., Naval Research Laboratory could be listed as U.S. Naval Research Laboratory, Naval Research Lab, NRL, or U.S. NRL). We chose to manually clean and resolve the top 200 institutions authoring papers in our corpus, accounting for 100,158 papers (74% of all papers returned). Our country analysis could include all 136,008 papers because institutions are affiliated with countries in the OpenAlex database in a standard way, which does not require resolution. Future analysis may benefit from entity resolution of the remaining papers in our dataset.

- Five of the top 10 academic institutes co-authoring most frequently with the DOD's research institutions are home to a DOD-affiliated research center, potentially indicating the importance of established DOD relationships or contractual vehicles outside of purely academic exchanges and grants.
- Of 136,000 DOD-affiliated papers reviewed for international collaborations, the top 5 most frequent international collaborations are, in order, the 27 member states of the European Union, the United Kingdom, Canada, China, and Japan. Of these, the European Union is by far the most frequent collaborator, while collaborations with China have declined since 2019.

Introduction

Despite budget pressures and immediate operational concerns, the U.S. military consistently invests in fundamental research and development (R&D). Those research efforts also support the work of academic and private researchers across the country and around the world. Many of the details of the DOD's R&D investments are classified or not publicly released, but there is a sliver of research that can be openly observed in academic publications that credit DOD-affiliated authors or the DOD's funding.

This analysis looks specifically at those papers that were authored by researchers affiliated with the DOD in the OpenAlex database¹, an open-source academic literature database, to illuminate the DOD's research publication trends. Here we define DOD affiliation as a researcher working on research at a DOD organization (such as the U.S. Army Research Laboratory or the U.S. Naval Research Laboratory) or at one of the DOD's federally funded research and development centers or university affiliated research centers (FFRDCs/UARCs) which are described below.

Background

In general, the DOD funds R&D to ensure “continuous advancement of technology and innovation within the DOD enterprise.”² This broad interest supports research spanning everything from missiles, tanks, ships, and aircraft, to satellite communications, enterprise software solutions, and healthcare. It also drives

*“The United States’ technological edge has long been the foundation of our military advantage.”
-2022 U.S. National Defense Strategy*

investments not just in applied research, which is often sensitive or classified, but also in fundamental research efforts, which “ordinarily are published and shared broadly within the scientific community,” per U.S. policy.³

Various organizations within the Office of the Secretary of Defense for Research and Engineering (OSD (R&E)) and the military services are independently responsible for disbursing the R&D funds allocated to them

in the DOD budget. Each organization is driven by unique motivations, for example, the Uniformed Services University Health System most frequently pursues health-related research, whereas the Army Space and Missile Defense Command is more likely to

pursue research on missile defense. There is no central organization responsible for choosing or prioritizing among all DOD R&D projects, though OSD(R&E) does provide strategic guidance.⁴

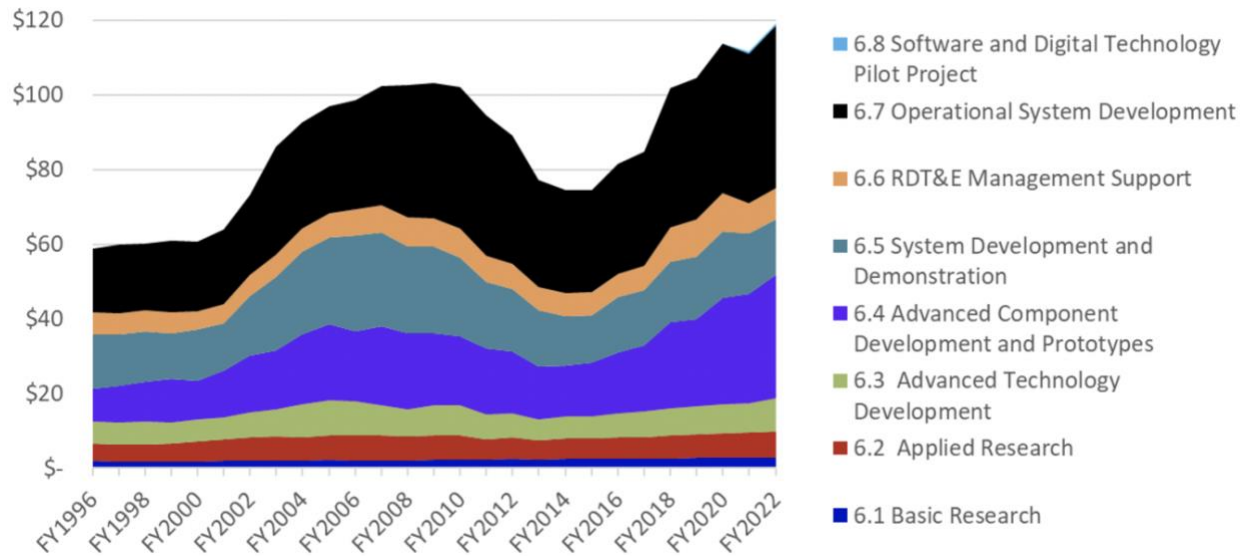
Organizations in the DOD can fund research either by transferring money to a government-run laboratory (for example, the U.S. Army or U.S. Naval Research Laboratory) or to an external performer (like an FFRDC/UARC or a university) via a contract, grant, or other cooperative agreement. Therefore, research papers that came out of research funded by the DOD may not include an author affiliated with the DOD. Many university researchers receive funding from the DOD to perform research, and while normally those researchers will acknowledge funding from the DOD in the paper, that information is inconsistently reported and is “fairly limited” in the OpenAlex database.⁵ Accordingly, this analysis examines only those papers with an author that is affiliated with the DOD, and not those papers that are solely funded by the DOD but do not include a DOD-affiliated author.

The DOD categorizes its R&D funding into what it calls budget activities, which it numbers from 1 through 8. The DOD guidance is that research funded by budget activities 1 (named “basic research”) and 2 (named “applied research”) “are to remain unrestricted to the maximum amount possible.” DOD funding for budget activities 3 and higher is generally considered more mature, and the results are frequently classified. Although there is no hard and fast rule for or against publication (or classification) at any level, it can be assumed that most published papers reflect efforts funded as basic or applied research (budget activities 1 and 2 respectively).⁶

“The Department of Defense (DOD) fully supports free scientific exchanges and dissemination of research results to the maximum extent possible.”
-Ashton Carter, Memorandum on Fundamental Research, 2010

Figure 1 shows the DOD’s overall R&D budget, delineated by budget activities (labeled 6.1-6.8 in the chart), and makes clear that the budget for activities in the basic and applied categories are low relative to the DOD’s overall R&D budget.⁷ This is an important point to keep in mind when examining research papers affiliated with the DOD, since those papers only reflect a small portion of its ongoing R&D.

Figure 1. DOD’s Research, Development, Test, and Evaluation Funding by Budget Activity, FY1996-FY2022



Note: Figures adjusted to constant FY2022 dollars using Table 10.1 of the Historical Tables from the President’s FY 2023 budget.

Source: Congressional Research Service.⁸

Incentives and Disincentives for Publishing DOD Research Papers

There are significant incentives pushing for and against the publication of the DOD’s research. Among the incentives to publish fundamental research is guidance from senior DOD leaders via official memoranda and National Security Decision Directive 189, which directs that, “to the maximum extent possible, the products of fundamental research remain unrestricted.”⁹ Beyond official guidance and policy incentives, papers that acknowledge the DOD’s involvement can help attract talent to the DOD’s laboratories or retain talent within defense laboratories. Similarly, these papers can build the reputation of the DOD as a leading technical institution among potential allies and competitors.¹⁰ Finally, greater public access to the DOD’s research enables connections to the broader ecosystem of discovery and important scientific breakthroughs useful to the DOD.¹¹

The forces pushing towards publication also come from external researchers and research institutions themselves. Research institutions benefit reputationally from an affiliation with high-impact research in the DOD and can use past papers to attract talent or future funding, either from the DOD or other funding organizations. The

reputational benefit is also important to the researchers themselves, who have career incentives to publish their work.

Pulling against those incentives to publish, however, are deep-seated and widespread concerns about research security, including foreign interference, theft of intellectual property, and the use of innovations by authoritarian regimes, criminals, terrorists, and competitor nations.¹² These concerns manifest in several ways that ultimately discourage publication, including the official classification of research results as secrets.

Even when research is unclassified, however, private sector, federal laboratory, and FFRDC/UARC researchers have less incentive to publish than their colleagues in academia. These researchers may be equally if not better rewarded for sharing reports of their research in DOD-only conferences or privately with their bosses and government sponsors—who may influence or ultimately control researchers' careers and who may see more risk than reward in publishing. R&D contracts are often based on the labor hours of researchers, and government funders may prefer those researchers to focus on completing government work and reports, rather than preparing and revising submissions to conferences or academic publications. Finally, researchers from government or FFRDC/UARC institutions must often navigate lengthy review and approval processes intended to reduce the risk that any sensitive, classified, proprietary, or export-controlled information is published, or that any government sponsor might find objectionable for any reason.¹³

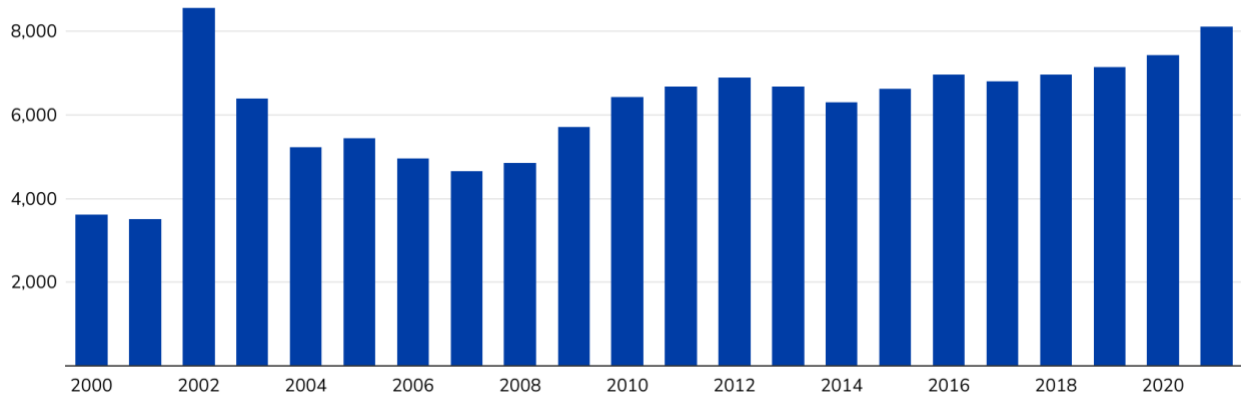
The mix of incentives for each of the actors in the DOD-supported researcher community inevitably affects what research is ultimately published and visible in the academic literature and, together with the above information about funding for basic and applied research, provides further context for understanding the collection of papers published by the DOD and the analysis that follows.

Identifying DOD Research Papers through DOD-Affiliated Institutions

For this paper, we identified DOD-affiliated research papers in the OpenAlex database by selecting those papers that list an author affiliated with an institution known to be wholly or mostly conducting research for the DOD. Applying this definition within the OpenAlex dataset presented some complications, which we address in Appendix A, but resulted in an inventory of 136,008 papers from between 2000 and 2021. The total number of papers represents less than one percent of all papers that list an author in OpenAlex.¹⁴ Figure 2 shows the quantity of DOD-affiliated papers from 2000

to 2021, showing that since 2017, the annual number of research papers has steadily, if slowly, increased.

Figure 2. Research Papers with One or More DOD-Affiliated Authors, 2000-2021



Source: OpenAlex.

The papers in this collection reflect DOD-affiliated institutions that are one of three of the following types:

Department of Defense Laboratories and Research Organizations

Among the DOD laboratories and research organizations are the well-known U.S. Army, Naval, and Air Force Research Laboratories but this category also includes smaller and more narrowly focused federal labs, such as the U.S. Army Research Institute for the Behavioral and Social Sciences, the Naval Medical Research Command, and the Joint Warfare Analysis Center.¹⁵ These laboratories employ tens of thousands of scientists and engineers across the country.¹⁶

Department of Defense FFRDCs and UARCs

Existing at the intersection of government, academia, and industry are the nation's FFRDCs and university affiliated research centers (UARCs). These non-profit organizations are established by law or policy with special abilities to contract with the government, and the DOD FFRDCs/UARCs included in this analysis can hold both classified and proprietary information as a part of their long-term, strategic relationship. They are expected to fill the gaps that may exist in academia, government, and the private sector, or act as a bridging organization between research

occurring within each. Sometimes these organizations are a small part of a much larger research organization (i.e., the Stevens Institute of Technology's Systems Engineering Research Center), and sometimes they are a more significant entity, either part of or separate from another organization (i.e., the Massachusetts Institute of Technology Lincoln Laboratory and the Aerospace Corporation, respectively).

Department of Defense Hospitals and Medical Training Programs Medical Research Activities

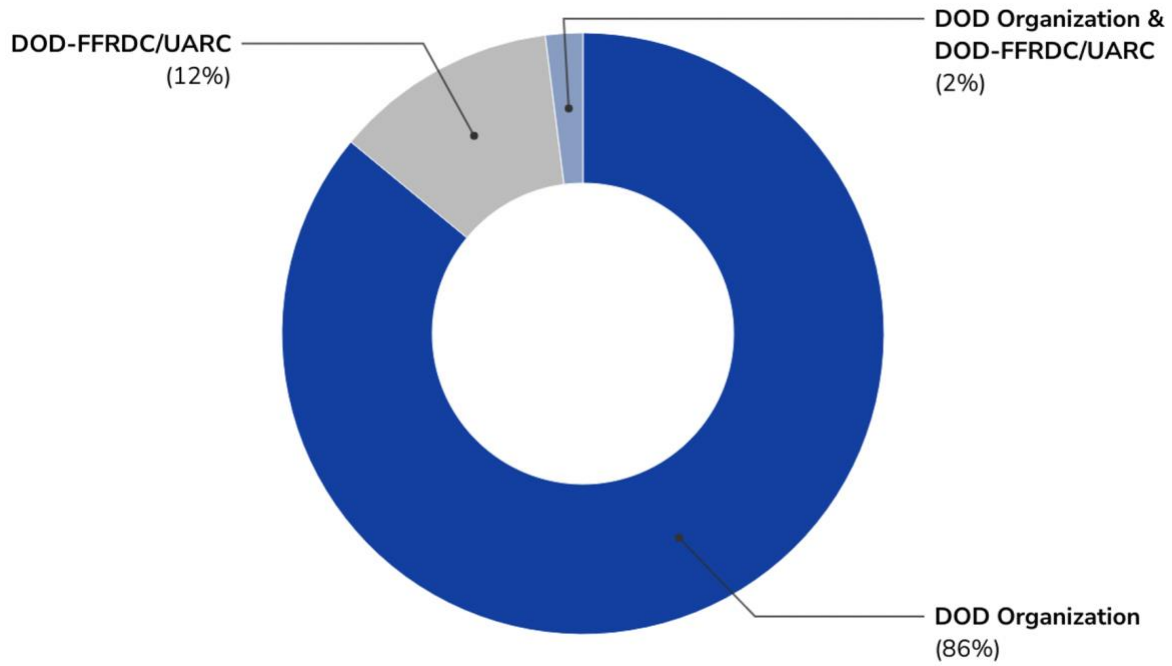
The DOD's Military Health Service provides care to 9.6 million service members, veterans, and their families, and so it has an established interest in furthering R&D on military-community healthcare issues. In pursuit of that interest, the DOD maintains hospitals and medical training programs where medical research is conducted and published. The most significant of these institutions is the Uniformed Services University of the Health Sciences (USUHS), the nation's only federal health sciences university.¹⁷

DOD-Affiliated Author Trends

Since each paper in the dataset may have multiple authors, some who are from DOD-affiliated organizations and some who are not, we took the top 200 organizations cited in our search results, accounting for 100,158 or 74% of all the papers returned, and manually annotated the list to resolve duplications and categorize the entities as either DOD-affiliated or non-DOD affiliated, and as academia, other governmental, private for-profit, non-profit, or international (including foreign academic and non-profit institutions).^{*} Of the 100,158 manually resolved DOD-authored papers, 86% included a DOD author, 12% included an FFRDC/UARC author, and 2% included both a DOD and an FFRDC or UARC author (Figure 3).

^{*} The original set of 136,008 papers had numerous instances where one institution was listed in multiple ways. For example, the Naval Research Laboratory could be listed as U.S. Naval Research Laboratory, or Naval Research Lab, or NRL, or U.S. NRL. We chose to clean and compile the 200 institutions with the highest number of papers returned in our search for this analysis (accounting for 74% of all papers returned), but future analysis may benefit from a more comprehensive entity resolution.

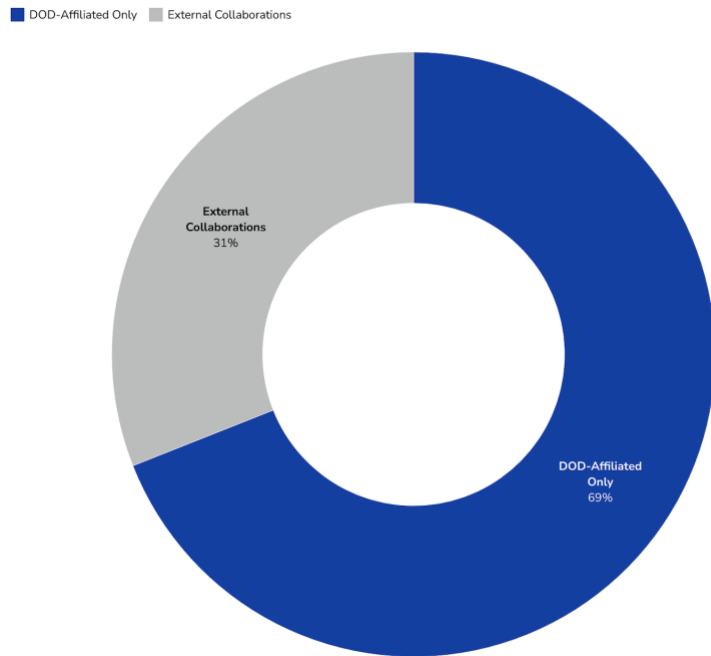
Figure 3. Papers by Type of DOD-Affiliated Author, 2000-2021



Source: OpenAlex.

Of all the papers, 69% had only these DOD-affiliated authors listed (either DOD labs or FFRDCs/UARCs), whereas 31% included a collaborator from a non-DOD-affiliated institution (Figure 4).

Figure 4. Papers with Only DOD-Affiliated Authors vs. Those with External Co-Authors, 2000-2021

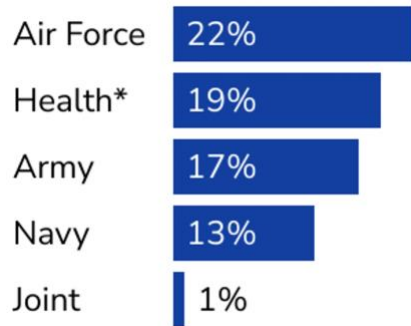


Source: OpenAlex.

We grouped all the DOD organizations listed in our resolved list of top institutions (100,158 papers) by service: Army, Navy, Air Force, Joint (to account for affiliations listed as the Department of Defense or National Defense University), and Health (representing medical research commands, regardless of service affiliation).

We found that the Air Force led the services with the greatest number of papers, but somewhat surprisingly, military health institutions were the second most frequently listed. This large number may be attributable to the military's investment in health research, the less sensitive nature of health research compared to weapons research, and the incentives for doctors, and in particular physicians at teaching hospitals, to publish (Figure 5).

Figure 5. Military Service Affiliations of Papers by Authors from DOD Organizations, 2000-2021



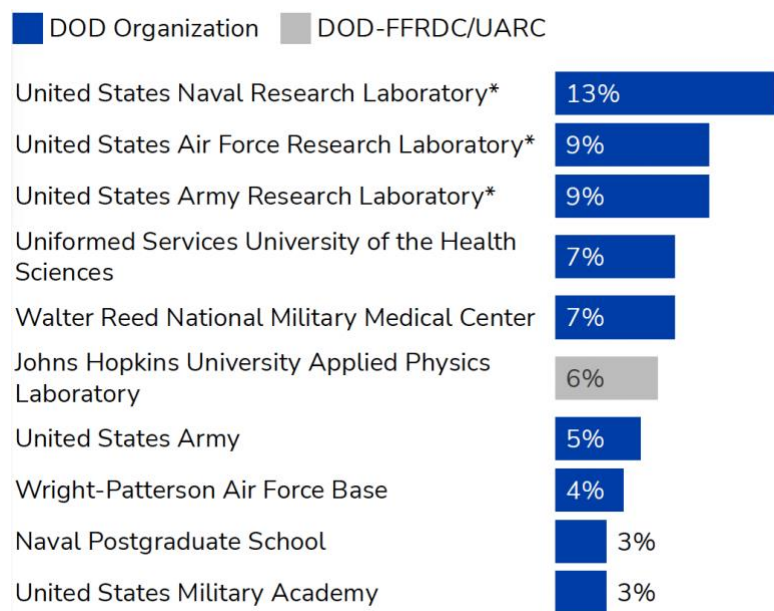
* We included USUHS, all Walter Reed commands, and any military medical center or treatment facility in the category of “health.”

Source: OpenAlex. Percentages represent the share of papers from the set of 100,158 entity-resolved papers.

Top 10 Institutional Affiliations

The top 10 institutional affiliations listed in our corpus of 100,158 papers with manually resolved affiliations are shown in Figure 6, with DOD organizations depicted in dark blue, and DOD-affiliated FFRDCs and UARCs depicted in gray.

Figure 6. Top 10 Author Affiliations on Papers with DOD-Affiliated Authors, 2000-2021



* We include authors reporting affiliation with the Office of Naval Research (ONR) in the total papers for the Naval Research Lab (NRL), since NRL reports to ONR. We approached the Army Research Lab similarly (reporting to the Army Research Office). The Air Force Research Lab, is the parent organization of the Air Force Office of Scientific Research (AFOSR); nevertheless, we report both here as United States Air Force Research Lab.

Source: OpenAlex. Percentages represent the share of papers from the set of 100,158 entity-resolved papers.

Unsurprisingly, the organizations that oversee and manage the majority of basic research funding dominate the top of the list. Furthermore, presumably, the majority of authors listing a service as their institutional affiliation (i.e., “Army”) are a part of a sub-organization in that service, such as the Army Research Office. A similar problem exists for the Wright-Patterson Air Force Base. As a military organization, the base itself employs no researchers; however, the base is home to five separate organizations conducting research: the Air Force Research Laboratory, the Air Force Institute of Technology, the National Air and Space Intelligence Command, the Air Force Materiel

Command, and a Naval Medical Research Unit Dayton.* We did not attempt to resolve the specific units for authors who listed a base or a service affiliation. As the chart shows, many authors are affiliated with a service or a service research laboratory. After service-affiliated labs, DOD medical facilities are top publishers, including the Uniformed Services University of the Health Sciences and the Walter Reed National Military Medical Center. Rounding out the list of DOD organizations are two educational institutions: the Naval Postgraduate School in Monterey, California, and the United States Military Academy in West Point, New York.

Also among the list of top 10 institutions is the nation's largest UARC, the Johns Hopkins Applied Physics Laboratory (JHU-APL). JHU-APL was included in the search terms as it is listed on the DOD's FFRDC/UARC list and has a long history of working in national security, beginning in World War II. While the majority of JHU-APL's work is dedicated to national security, a significant amount of research is affiliated with non-defense contracts as well, for example, scientific research papers funded by NASA. In this report, we did not attempt to resolve the source of funding or likely affiliation of the papers (NASA or DOD).

Co-authorship Outside of DOD-Affiliated Organizations

While this analysis is focused on papers with DOD-affiliated authors, a subset of those papers (31%, or 31,049 papers) have co-authors from the broader research ecosystem, to include universities and colleges, small and large companies, federal government labs, hospitals, and even international organizations. More specifically, of papers co-authored with external collaborators, 83% included a researcher from an academic institution, 16% from another government research lab (for example, NASA's Jet Propulsion Laboratory), 9% from a private for-profit organization, 5% from a non-profit research organization, and 4% from international researchers.¹⁸ These co-authored papers indicate how connected the DOD is to the broader research ecosystem, but it is important to note that this is only an indication. The DOD funds a great deal of extramural research that does not result in a published paper with a DOD-affiliated author.¹⁹

*We chose to treat Wright-Patterson AFB as an independent entity within the Air Force, though certainly those papers could be divided by the sub-commands at the base as well, and one of them is affiliated with the Navy. We assume the number of papers associated with the navy from Wright-Patterson AFB is low enough to accept the error.

Organizational affiliations listed in the papers we found which were not a part of the DOD-affiliated list include:

Academia

The DOD is a substantial source of funding for academia and especially for researchers in computer science, materials science, and aerospace, electrical, mechanical, and industrial engineering.²⁰ The DOD also funds research at academic hospitals and medical research centers. The DOD allocates over half of its basic research budget to academic institutions across the U.S. and around the world in its efforts to avoid technological surprises.²¹

Other Government Laboratories

The DOD maintains a robust network of laboratories, but it also collaborates with other government laboratories, such as those maintained by the Department of Energy or the National Aeronautics and Space Administration (NASA). These facilities can be especially important partners for research that requires highly specialized test facilities, such as NASA's supersonic wind tunnels.

Private For-Profit Organizations

The private sector is a well-known source of cutting-edge research and spends more on R&D than the federal government. Many private companies perform research for business purposes, which can sometimes align with the DOD's research interests and capabilities. When interests overlap, the DOD may choose to enter into a cooperative research and development agreement (CRADA) to jointly conduct research.²² A CRADA is appropriate in any instance where government and business research interests are aligned, but especially useful for the purpose of tech transfer from the federal lab to the private sector. Small business innovation research and small business technology transfer programs (SBIRs/STTRs) are also vehicles by which the government could formally collaborate on research with a small business. For reasons explained earlier, research papers from these agreements are seldom published. That said, previous CSET research analyzing U.S. government grants data indicates that the DOD awards grants for AI research to industry at a notably higher rate than other government departments.²³

Private Non-Profit Research Organizations

In the United States, nonprofit research organizations are 501C(3) entities that are not a part of another for-profit, FFRDC/UARC, or higher education institution.²⁴ These institutions can conduct or simply fund research and examples include Battelle, SRI International, and the National Academy of Sciences, Engineering, and Medicine, as well as foundations like the American Cancer Society or the Bill and Melinda Gates Foundation.²⁵ In 2020, private non-profit research organizations reported employing more than 200,000 people and expending \$28B in research, 75% of which was on health sciences and related fields. Overall, non-profit research organizations are expending 4% of the estimated total spent on R&D in the United States (government and private sector funding).²⁶

International Research Organizations

Finally, the DOD's research efforts are notable for allocating more funds to international researchers than any other basic research funding organization in the U.S. government. Furthermore, unlike other federal organizations, the DOD can directly fund foreign researchers in foreign institutions.²⁷ The DOD's strong interest in funding foreign research is related in part to its efforts to establish and build international partnerships for national security purposes. It is also driven by a desire to access R&D conducted around the world. The share of U.S. versus international R&D expenditures for scientific research is approximately 31% U.S. and 69% rest of world today. This is a complete reversal from the days of the Cold War, when the United States spent 69% of global research dollars and the rest of the world only 31%.²⁸

Co-authorship Trends with Outside Organizations

As previously noted, 31% of the papers with DOD-affiliated authors had co-authors from the broader research ecosystem (31,049 papers). 83% of these listed co-authors from academic institutions, 16% were co-authored with researchers from non-DOD government research laboratories, 9% were co-authored with researchers from private for-profit organizations, 5% were co-authored with researchers from non-profit research organizations, and 4% were co-authored with researchers from international researcher organizations. These percentages are very different from national estimates of which institutions are performing R&D within the United States, where businesses dominate.²⁹ While some portion of the difference could be attributed to incentives for industry to avoid publicly revealing their research, industry is co-authoring a large fraction of papers in some emerging tech research areas (e.g., 40% of papers at leading

AI conferences).³⁰ While there may be many good reasons for such a small number of industry-affiliated co-authored papers, the magnitude of the difference may warrant closer examination by the DOD's leaders.

Top 10 External Collaborator Affiliations

Table 1 lists the top external co-author institutions by type among our resolved set of DOD-affiliated papers. Of the academic institutions, the list is topped by prestigious universities with top engineering and computer science programs, beginning with the Massachusetts Institute of Technology, and also includes universities with distinguished mechanical engineering programs, such as the University of Dayton. Interestingly, 5 of the top 10 academic institutions are also home to an FFRDC or a UARC (MIT, University of Maryland, University of Washington, Johns Hopkins University, and Pennsylvania State University). Additionally, while the University of Dayton does not have an official FFRDC or UARC, it does house the University of Dayton Research Institute (UDRI), which receives more than 95% of its funding from federal agencies, including the DOD, and is proximate to the Wright Patterson Air Force Base, where AFRL is headquartered.³¹

Of the top 10 other governmental research institutions listed, 6 are affiliated with space research and NASA, 3 are affiliated with health research, and the final member of the group is the Department of Commerce's National Institute of Standards and Technology (NIST).

Only three non-profit organizations are responsible for all the papers with non-profit co-authors. Of these, the Henry M. Jackson Foundation is by far the most prolific, and has a stated mission to "advance military medicine."³²

There are only nine private, for-profit organizations in the list of the top 200 entities we examined: Science Applications International Corporation (SAIC), Leidos, Lockheed Martin, General Dynamics, and Boeing are well-known government contractors. UES is a Dayton, Ohio-based business that works with the Air Force Research Laboratory, U.S. Navy, and U.S. Army.³³ University Surgical Associates is a private company and "one of the largest multi-specialty surgical groups in the southeast," serving mostly the Chattanooga, Tennessee region.³⁴

Finally, as detailed earlier, among federal R&D funding organizations, the DOD directly allocates more funds to international researchers than any other major basic research funding organization in the U.S. government.³⁵ While our data does not fully capture the funding the DOD provides to international organizations, when we conducted the

fine grained identity resolution of the top 200 institutions in our dataset of papers, we found 5 international institutions, including some of the world’s most well-respected research institutions: the French National Centre for Scientific Research, Imperial College London, the Max-Planck Society, University College London, and the University of Oxford.³⁶

Table 1. Top Co-author Institutions, by Type

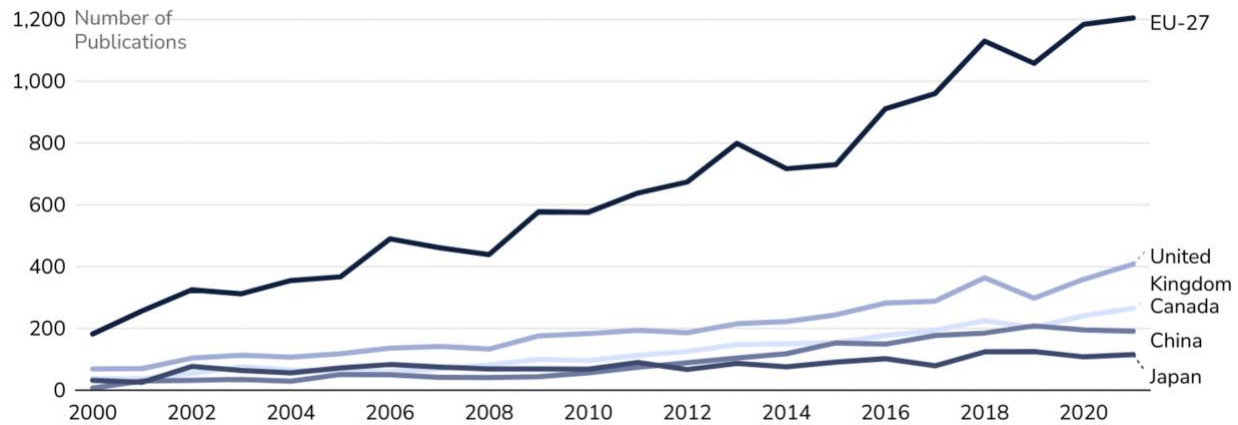
Academic Top 10	Other Governmental Top 10	Private Sector Companies
<ol style="list-style-type: none"> 1. Massachusetts Institute of Technology 2. University of Maryland, College Park 3. University of Washington 4. Johns Hopkins University 5. University of Michigan, Ann Arbor 6. University of Dayton 7. University of Colorado, Boulder 8. University of California, Los Angeles 9. George Mason University 10. Pennsylvania State University 	<ol style="list-style-type: none"> 1. Goddard Space Flight Center 2. National Institutes of Health 3. Jet Propulsion Laboratory 4. Langley Research Center 5. National Institute of Standards and Technology 6. Ames Research Center 7. National Cancer Institute 8. United States Geological Survey 9. Glenn Research Center 10. National Institute of Allergy and Infectious Diseases 	<ol style="list-style-type: none"> 1. Science Applications International Corporation 2. UES 3. Leidos 4. Lockheed Martin 5. Sotera Defense Solutions 6. General Dynamics 7. University Surgical Associates 8. Boeing 9. Northrop Grumman
	Non-Profit Organizations	International Organizations
<ol style="list-style-type: none"> 1. Henry M. Jackson Foundation 2. Planetary Science Institute 3. National Academies of Sciences, Engineering, and Medicine 	<ol style="list-style-type: none"> 1. French National Centre for Scientific Research 2. Imperial College London 3. The Max-Planck Society 4. University College London 5. The University of Oxford 	

International Research Co-authorship Further Analysis

OpenAlex provides national affiliations for papers according to the author's institutional affiliations. With these country affiliations, we can easily analyze international collaborations for the entire set of DOD-affiliated papers (136,008 papers), instead of just the subset of 100,108 papers which were authored by one of the top 200 institutions for which we conducted fine-grained entity resolution.

Figure 8 displays international collaborations by country over time, starting in 2000, with the 27 European Union members (EU-27) grouped together. Following the EU-27, the most frequently listed countries in our data set were (in order) the United Kingdom, followed by Canada, China, and Japan.*

Figure 8. Top 5 Foreign Affiliations Represented in DOD-Affiliated Corpus, 2000-2021



Source: OpenAlex.

China's presence on the list of top international collaborators may be surprising to those most familiar with China as only a military competitor to the United States, however, its inclusion as a top collaborator reflects its status as one of the most productive nations for science and engineering researchers overall. Several studies have recently concluded that China has overtaken the United States both in terms of the quantity of scientific research papers and the impact of those papers.³⁷ Despite China's rise in research papers, and unlike other top international collaborators, co-authorship between DOD-affiliated authors and China-based authors is decreasing, from a high in 2019 of 245 papers to 219 papers in 2021. Only 2,330 papers total with authors from U.S. and Chinese institutions were found between 2000 and 2021,

* Papers affiliated with more than one country are counted once for each country listed.

representing 2% of all papers found in our search and 8% of all papers with international collaborations.

Research Collaborations with People’s Liberation Army-Affiliated Institutions

Between 2000 and 2023, we found a small subset of papers (less than 25 in any given year) where the China-based author was affiliated with one of what’s known as

Seven Sons of National Defense

Beijing Institute of Technology

Beijing University of Aeronautics and Astronautics

Harbin Engineering University

Harbin Institute of Technology

Nanjing University of Aeronautics and Astronautics

Nanjing University of Science and Technology

Northwestern Polytechnical University

China’s “Seven Sons of National Defense.”

These institutions have historical ties with China’s defense industry and are administered by the State Administration for Science, Technology, and Industry for National Defense.

Each institution has a different area of focus, and the organizations most frequently

appearing included Beihang University; the Harbin Institute of Technology; and the

Northwest Polytechnical University. Beihang

University is best known for aeronautics and astronautics research and training, the Harbin

Institute of Technology is closely aligned with

China’s shipbuilding industry; and Northwestern

Polytechnical University (NWPU) is considered

the top talent source for China’s largest defense

company.³⁸

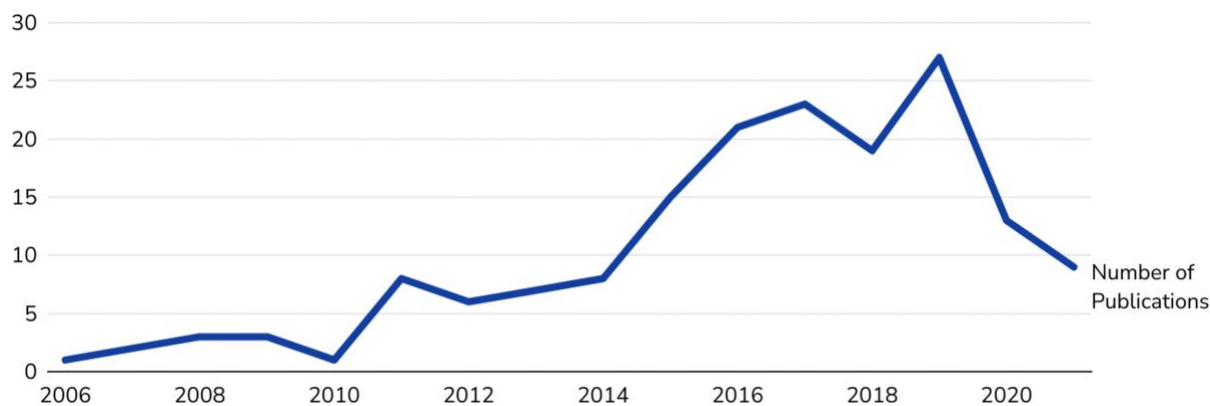
The value or risk of these collaborations should be understood in context. Some of the papers that listed a co-author from one of the Seven Sons were concerned with therapies for cancer, the nature of solar wind, and planetary defense against asteroids. A handful of those papers also clearly represented international research efforts, with dozens of authors from multiple countries.

That said, we also found papers with both DOD-affiliated co-authors and Seven Sons-affiliated co-authors on underwater acoustics, sensor jamming, drones, swarms, and facial recognition technologies. It is beyond the scope of this paper to determine who benefited more in each of these collaborations, but the fact of the collaboration may be of concern to leadership in both countries.

Looking at co-authorship with Seven Sons over time (Figure 9), there was a precipitous drop in co-authorship in 2019, coinciding with the COVID-19 pandemic and

significantly more political pressure around U.S. research security. That pressure came in the form of political rhetoric, but also from the 2019 National Defense Authorization Act (NDAA, passed August 2018), and the January 2021 National Security Presidential Memorandum–33 (NSPM–33) which were focused on protecting U.S. R&D from “foreign government interference and exploitation,” specifically identifying the PRC as a nation that does not uphold the norms of open scientific exchange.³⁹ More recently, the USD(R&E) issued a memorandum instructing military organizations to conduct risk-based security reviews of fundamental research, including specific discouragement of working with institutions like the Seven Sons of Defense.⁴⁰

Figure 9. Count of Papers Co-authored by DOD-Affiliated and Seven Sons-Affiliated Authors, 2006-2022



Source: OpenAlex.

Conclusion and Recommendations

This paper examined the institutions engaged in DOD-affiliated research by identifying all papers that credit a DOD-affiliated author. Of the 100,158 papers we found and manually reviewed in our search, about 31% listed a co-author from an institution not affiliated with the DOD. The vast majority of those external collaborations were with academic institutions, and the top collaborators in academia were among the most distinguished universities in the United States, though it is notable that half of the top 10 institutions co-authoring papers with DOD researchers are also home to an FFRDC/UARC. This indicates that FFRDCs/UARCs may enable higher levels of engagement between their universities and the DOD. If the DOD wishes to further diversify its engagement with academia, it may consider how to replicate the FFRDC/UARC advantage on other campuses.

The DOD's rate of collaboration with private industry (9%) is relatively low compared to private industry's R&D efforts. Given the size of this discrepancy, and the rising number of papers by large companies on certain emerging technologies (40% of top AI conference papers include an industry author, for example), the DOD may wish to reassess its approach to collaborative research with businesses, especially in AI research.⁴¹ This recommendation comes with an acknowledgement that the number of co-authored papers will never be as great as the amount of ongoing research at businesses, and there is evidence that DOD is already awarding research grants to industry at a higher rate than other U.S. government organizations.⁴²

Finally, the DOD co-authors papers with distinguished international institutions, especially those of allied nations, but Chinese institutions are also among the most frequent international collaborators, behind Canada and ahead of Japan. China's status as a global research leader makes collaborations attractive, but the DOD must consider the advantages and disadvantages of these collaborations, particularly on sensitive technologies and with institutions affiliated with the PLA. The precipitous drop in co-authorship with members of China's Seven Sons of National Defense indicates that the risk of this sort of research is diminishing rapidly, but the DOD will have to constantly re-assess the advantages and disadvantages of co-authorship with Chinese institutions in the midst of geopolitical tensions.

Overall, examining these research papers gives a window into the DOD's fundamental research. The DOD may benefit from consistently analyzing and monitoring DOD-authored and, where possible, DOD-funded research papers. Future research directions could include more detailed analysis of research subjects covered by the corpus of DOD-affiliated papers, investigations into the DOD organizations with notably high rates of collaboration, and an analysis of the DOD's research ecosystem that takes into account information gleaned from R&D grants and contracts databases.

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Appendix A

To conduct our analysis, we defined DOD-affiliated papers as those written by authors doing DOD-sponsored research and affiliated with either:

- The Department of Defense or one of its subordinate organizations, including the military service laboratories, military hospitals, military academies, military post-graduate schools, etc.
- An FFRDCs formally sponsored by the DOD or a DOD organization
- A UARC formally sponsored by the DOD or a DOD organization

Gathering a list of these entities is straightforward; however, delineating the degree to which papers from authors at FFRDCs and UARCs reflect DOD-sponsored research is more complicated. Several FFRDCs/UARCs are very small parts of larger institutions that are not conducting DOD-sponsored research. For example, the Stevens Institute of Technology is a private research institution with over 900 faculty and staff located just outside New York City. In addition to educating its more than 9,000 undergraduate and graduate students, Stevens runs the DOD UARCs called the Systems Engineering Research Center (SERC), which is a network of researchers that extends across more than 20 U.S. universities. A search for “Stevens Institute of Technology Systems Engineering Research Center” returns no results. A search for the “Stevens Institute of Technology,” however, returned more than 10,000 results. We contacted the SERC director, who confirmed that most researchers simply list the parent institution name in their papers (Stevens Institute of Technology) and then provided a list of approximately 400 papers directly tied to the UARC between 2000 and 2021. The Southwest Research Institute has a similar issue, where a majority of the researchers list the parent institution (SWRI) versus the specific FFRDC/UARC they support (the Army’s Fuels and Lubricants Research Facility), which represents only a small portion of SWRI’s research. In both instances, we chose to exclude these institutions from our search terms because so many of the papers returned were not research sponsored by the DOD.

The Johns Hopkins Applied Physics Laboratory has a reverse issue. The majority of JHU-APL’s funded work is for the DOD; however, a smaller portion is dedicated to research affiliated with NASA. Because the majority of JHU-APL’s work as an institution is dedicated to the DOD, we chose to include JHU-APL in our list of search

terms but acknowledge that an unknown number of JHU-APL's papers are not connected to the DOD.

With the intent and complications in mind, we generated our regular expression search terms through a 4-step approach: first, we drew from the USD(R&E) list of defense laboratories and centers and added variations on potential organization names (i.e., "Naval Undersea Warfare Center" as well as "NUWC").⁴³ Second, we searched U.S. Code 10 for any other institutional mentions, and as a consequence, added all military-affiliated educational institutions, such as the service academies. Third, we then conducted a search of OpenAlex with the broad terms "Army," "Navy," and "Air Force" and eliminated any entries we had already accounted for. We then reviewed the top 5,000 institutions by publication count to identify commands that may have been missed earlier but which were clearly affiliated with the U.S. Department of Defense, this step surfaced, for example, Wright-Patterson Air Force Base, which is host to a number of separate research commands. Finally, we eliminated from our search terms those parent institutions that contain a DOD-FFRDC/UARC but only perform a small amount of R&D for the DOD, relative to their other research activities.

Endnotes

¹ Available at <https://openalex.org/>.

² "About USD(R&E)," *DoD Research & Engineering, OUSD(R&E)*, <https://www.cto.mil/about/>, accessed March, 24, 2023.

³ National Security Decision Directive 189. *National Policy on the Transfer of Scientific, Technical and Engineering Information*, September 21, 1985.

⁴ For more on the current DOD research and engineering vision see: Shyu, Heidi, "USD(R&E) Technology Vision for an Era of Competition," February 1, 2022, https://www.cto.mil/wp-content/uploads/2022/02/usdre_strategic_vision_critical_tech_areas.pdf.

⁵ "Grants," *OpenAlex API Documentation*, <https://docs.openalex.org/api-entities/works/work-object#grants>.

⁶ Encouragement to publish research under budget activity 2 is modified by the following guidance: "The research shall not be considered fundamental in those rare and exceptional circumstances where the 6.2 funded effort presents a high likelihood of disclosing performance characteristics of military systems or manufacturing technologies that are unique and critical to defense, and where agreement on restrictions have been recorded in the contract or grant." From: Carter, Ashton B., *Memorandum For the Secretaries of the Military Departments, Subject: Fundamental Research*, May 24, 2010.

⁷ Office of the Under Secretary of Defense (Comptroller/Chief Financial Officer), *Defense Budget Overview*, April 2022, https://comptroller.defense.gov/Portals/45/Documents/defbudget/FY2023/FY2023_Budget_Request_Overview_Book.pdf.

⁸ Congressional Research Service, *Department of Defense Research, Development, Test, and Evaluation (RDT&E): Appropriations Structure*, September 7, 2022, <https://sgp.fas.org/crs/natsec/R44711.pdf>.

⁹ Ashton B. Carter, *Memorandum For the Secretaries of the Military Departments, Subject: Fundamental Research*, May 24, 2010, and National Security Decision Directive 189. *National Policy on the Transfer of Scientific, Technical and Engineering Information*, September 21, 1985.

¹⁰ Daniele Rotolo, Roberto Camerani, Nicola Grassano, Ben R. Martin, "Why do firms publish? A systematic literature review and a conceptual framework," *Research Policy*, Volume 51, Issue 10, 2022, <https://doi.org/10.1016/j.respol.2022.104606>.

¹¹ Department of Defense, *Plan to establish public access to the results of federally funded research*, February 2015, https://discover.dtic.mil/wp-content/uploads/2018/06/dod_public_access_plan_feb2015.pdf.

¹² John Richardson, “Memorandum on Public Communication Guidance,” March 1, 2017, <https://www.documentcloud.org/documents/6556495-March-1-2017-Memo-John-Richardson-Public>.

¹³ For more information, see DOD Instruction 5230.09, Clearance of DOD Information for Public Release, January 25, 2019; and DOD Instruction 5230.29 Security and Policy Review of DOD Information for Public Release, February 8, 2022.

¹⁴ Not all papers in OpenAlex contain the names of authors, affiliated institutions, or funders.

¹⁵ “Defense Laboratories and Centers” *Chief Technology Officer*, 9 June 2019, <https://rt.cto.mil/wp-content/uploads/2019/06/2019-DoD-Laboratories-and-Centers-Map-6-7-19-x.pdf>.

¹⁶ “Defense Innovation Marketplace,” *Defense Technical Information Center*, Accessed March 24, 2023, <https://defenseinnovationmarketplace.dtic.mil/business-opportunities/laboratories/>.

¹⁷ Congressional Research Service, *FY2023 Budget Request for the Military Health System*, April 29, 2022, <https://crsreports.congress.gov/product/pdf/IF/IF12087/2>; and “Uniformed Services University of the Health Sciences,” *Defense Health Agency*, accessed March 24, 2023, <https://www.health.mil/About-MHS/OASDHA/Uniformed-Services-University-of-the-Health-Sciences>.

¹⁸ Some papers have authors from several different types of institutions, these papers are counted for each type of institution listed and so the percentage totals exceed 100%.

¹⁹ Inconsistencies in the way funders are acknowledged in papers, coupled with a sparsity of funding data in the OpenAlex dataset currently precludes meaningful analysis of DOD-funded research papers.

²⁰ Congressional Research Service, *Federal Research and Development (R&D) Funding: FY2022*, September 13, 2021, <https://crsreports.congress.gov/product/pdf/R/R46869/3>.

²¹ Congressional Research Service, *Federal Research and Development (R&D) Funding: FY2022*, September 13, 2021, <https://crsreports.congress.gov/product/pdf/R/R46869/3>; and Congressional Research Service, *Federally Funded Research and Development Centers (FFRDCs): Background and Issues for Congress*, April 3, 2020, <https://crsreports.congress.gov/product/pdf/R/R44629/5>; and Melissa Vetterkind, “Department of Defense Agency Budgets,” *American Association for the Advancement of Science*, Accessed March 25, 2023, <https://www.aaas.org/programs/r-d-budget-and-policy/department-defense>.

²² “Cooperative Research and Development Agreement (15 USC §3710a),” *Defense Acquisition University*, n.d., <https://aaf.dau.edu/aaf/contracting-cone/rd-agreements/crada/>.

²³ Schoeberl, Christian and Hanna Dohmen, “Spurring Science: Examining U.S. Grant Activity in AI,” *Center for Security and Emerging Technology*, November 2023.

- ²⁴ “Annual Business Survey 2021,” National Center for Science and Engineering Statistics, n.d., <https://nces.nsf.gov/surveys/annual-business-survey/2021#methodology>.
- ²⁵ For a more complete discussion of non-profit research entities see: National Research Council, *Measuring Research and Development Expenditures in the U.S. Nonprofit Sector: Conceptual and Design Issues: Summary of a Workshop*. Washington, DC: The National Academies Press. 2015. <https://doi.org/10.17226/21657>.
- ²⁶ Rhonda Britt, *U.S. Nonprofits Spent \$28 Billion on R&D Activities in FY 2020*. NSF 23-316. Alexandria, VA: National Science Foundation, <https://nces.nsf.gov/pubs/nsf23316>.
- ²⁷ Hottes, Alison K., Marjory S. Blumenthal, Jared Mondschein, Matthew Sargent, and Caroline Wesson, *International Basic Research Collaboration at the U.S. Department of Defense: An Overview*. Santa Monica, CA: RAND Corporation, 2023. https://www.rand.org/pubs/research_reports/RRA1579-1.html.
- ²⁸ Congressional Research Service, *Global Research and Development Expenditures: Fact Sheet*, September 14, 2022, <https://crsreports.congress.gov/product/pdf/R/R44283/15>.
- ²⁹ Businesses dominate and perform 71% of U.S. R&D expenditures from all sources, and academia performs only 13%, whereas non-profits perform 4%. National Center for Science and Engineering Statistics, *National Patterns of R&D Resources: 2019–20 Data Update Table 4*, <https://nces.nsf.gov/pubs/nsf22320#section10192>, Accessed October 18, 2023.
- ³⁰ Nur Ahmed, Muntasir Wahed, and Neil Thompson, “The growing influence of industry in AI research,” *Science*, March 2, 2023.
- ³¹ University of Dayton Research Institute, “University of Dayton, Fiscal Year 2023,” Accessed March 20, 2024, <https://udayton.edu/udri/about/statistics.php>.
- ³² “HJF,” *Henry M. Jackson Foundation*, <https://www.hjf.org/>.
- ³³ “About,,” *UES*, <https://www.ues.com/about>.
- ³⁴ “Who We Are,” *University Surgical Associates*, <https://universitysurgical.com/who-we-are/>.
- ³⁵ Alison K. Hottes, Marjory S. Blumenthal, and Jared Mondschein et al., *International Basic Research Collaboration at the U.S. Department of Defense: An Overview*, Santa Monica, CA, RAND Corporation, 2023, https://www.rand.org/pubs/research_reports/RRA1579-1.html.
- ³⁶ For more information about CNRS and the Max-Planck Society, see Centre national de la recherche scientifique, “The CNRS,” <https://www.cnrs.fr/en/cnrs#:~:text=The%20French%20National%20Centre%20for,challenges%20of%20today%20and%20tomorrow>; and Max-Planck Society, “Profile and vision.” <https://www.mpg.de/11761628/profile-visions>, Accessed April 3, 2023.

³⁷ Donna Lu, “China overtakes the US in scientific research output,” *The Guardian*, August 11, 2022. <https://www.theguardian.com/world/2022/aug/11/china-overtakes-the-us-in-scientific-research-output>.

Baker, Simon, “China overtakes United States on contribution to research in Nature Index,” *Nature Index*, May 19, 2023, <https://www.nature.com/articles/d41586-023-01705-7>.

³⁸ Ryan Fedasiuk and Emily Weinstein, “Universities and the Chinese Defense Technology Workforce,” *Center for Security and Emerging Technologies*, December 2020, <https://cset.georgetown.edu/wp-content/uploads/CSET-Universities-and-the-Chinese-Defense-Technology-Workforce.pdf> and Joske, Alex, “The China Defence Universities Tracker,” Australian Strategic Policy Institute, November 25, 2019, <https://www.aspi.org.au/report/china-defence-universities-tracker>.

³⁹ National Security Presidential Memorandum-33, “Presidential Memorandum on United States Government-Supported Research and Development National Security Policy,” January 14, 2021.

⁴⁰ Northwestern Polytechnic University, Harbin Institute of Technology, and Beihang University are each listed in U.S. government documents as problematic. For more information on the government’s review process and a list of entities of concern, see Under Secretary for Defense (Research and Engineering) memorandum, “Policy for Risk-Based Security Reviews of Fundamental Research,” June 8, 2023.

⁴¹ Ahmed, Nur, Muntasir Wahed, and Neil Thompson, “The growing influence of industry in AI research,” *Science*, March 2, 2023.

⁴² Schoeberl, Christian and Hanna Dohmen, “Spurring Science: Examining U.S. Grant Activity in AI,” *Center for Security and Emerging Technology*, November 2023.

⁴³ Defense Laboratories and Centers, *Chief Technology Officer*, June 9, 2019, <https://rt.cto.mil/wp-content/uploads/2019/06/2019-DoD-Laboratories-and-Centers-Map-6-7-19-x.pdf>.