Maryland
DEPARTMENT OF COMMERCE

Larry Hogan | Governor
Boyd Rutherford | Lt. Governor
Kelly M. Schulz | Secretary of Commerce

January 24, 2020

The Honorable Bill Ferguson
President, Maryland Senate
State House, H-107
Annapolis, Maryland 21401-1991

The Honorable Adrienne A. Jones
Speaker, Maryland House of Delegates
State House, H-101
Annapolis, Maryland 21401-1991

RE: Department of Commerce – Small Business Innovation Research and Technology Transfer – Study – Chapter 306 of 2019

Dear President Ferguson and Speaker Jones:

In accordance with Chapter 306 of 2019, the Department of Commerce is pleased to submit the Small Business Innovation Research and Technology Transfer study.

I look forward to your review of the report and will be pleased to respond to any questions. If my staff can be of further assistance, or if you have any questions regarding this report, please feel free to contact me at 410-767-6301.

Sincerely,

Kelly M. Schulz
Secretary

Enclosure

cc: The Honorable Brian J. Feldman
The Honorable Anne R. Kaiser
The Honorable Delores G. Kelley
The Honorable Lily Qi

Small Business Innovation Research and Technology Transfer – Study

Chapter 306 of 2019

January 23, 2020

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Executive Summary

Maryland is home to many federal resources, which provide employment and economic investment across the State. To ensure that these resources are taken advantage of appropriately, the Maryland Legislature passed Chapter 306 of the Acts of 2019, which required the Maryland Department of Commerce to explore issues surrounding Federal investment, research, and funding. After completing an extensive study, Commerce found the following:

(1)(i) explore ways to foster job creation and economic development in the State by capitalizing on the federal presence in the State.

The federal presence in Maryland runs deep. Almost 176 thousand federal civilian employees work in Maryland, along with 50,172 active-duty and reserve military members. Per capita, Maryland has more federal civilian jobs than any other State. Moreover, an estimated 295 thousand full-time federal civilian workers reside in Maryland, representing about one out of 10 employed civilian Maryland residents.

In FY2019, over $33 billion in federal contract work was performed in Maryland, ranking it fourth in total contract spending and third in per-capita spending. In addition, over $15 billion in federal grants were awarded to recipients in Maryland. Contract and grant spending in Maryland makes up 12.5 percent of the State's GDP.

Maryland ranks 7th in total research expenditures and third in the share of federal R&D expenditures expended by the federal research sector, receiving $17 billion in federal funding for research. This represented almost 79 percent of the total funds expended in Maryland on research and development. Maryland's federal research centers spend some $11 billion on R&D activities, making the State responsible for over one-third of the nation's total federal laboratory research expenditures.

(1)(ii) explore ways to encourage small businesses to engage in federal research and development that has the potential for commercialization.

Like the rest of the nation, the vast majority of firms in Maryland are small businesses. Firms employing fewer than 50 people made up over 95 percent of all firms and employed over 730 thousand workers. Unfortunately, federal data shows that small business research spending has been declining, while spending at the largest companies has been significantly increasing. Both federal and state data show that most research funding from businesses of all sizes comes from the manufacturing and professional services sectors, making these industries the primary targets for increasing small business research spending.

While Maryland's small businesses have been successful at obtaining federal contract funding, they have been less successful at obtaining research funding. While 33.8 percent of all of Maryland's federal contract funding went to small businesses, this was true for only 18.8 percent of all awards for research. The four agencies that account for 95 percent of all research contracts in the State (Defense, HHS, NASA, and NSF) all cluster around this percentage.

(1)(iii) explore ways to facilitate the transfer of technology from small businesses.

The universe of federal technology transfer is complex. The sheer volume of federal research and the multiple ways in which a company could conceivably obtain transferred technology make it difficult for the uninitiated to become involved in the federal technology transfer system.

Federal Commercialization Channels. There are five major channels through which federal technology transfer activities occur:

1. *Commercial transfer*: The movement of knowledge or technology developed by a federal laboratory to private organizations or the commercial marketplace;
2. *Scientific dissemination*: Publications, conference papers, and working papers distributed through scientific or technical channels, or other forms of data dissemination;
3. *Export of resources*: Federal laboratory personnel made available to outside organizations with R&D needs, through collaborative agreements or other service mechanisms;
4. *Import of resources*: Outside technology or expertise brought in by a federal laboratory to enhance existing internal capabilities; and
5. *Dual use*: Development of technologies, products, or families of products with commercial and federal [mainly military] applications.[1]

The majority of federal tech transfer happens through collaborative R&D relationships:

- Cooperative Research & Development Agreements (CRADAs), the most common method;
- Entrepreneurial Leave Programs;
- Entrepreneur-in-Residence (EIR) Programs;
- Public-Private Entrepreneurial Partnerships;
- Strategic Partnership Programs;
- Use of Facilities Agreements;
- Visiting Scientist Programs; and
- Educational Partnership Agreements (EPAs).

The second most significant source of tech transfer is through licenses, either of patented or non-patented inventions or other intellectual property licenses.

The federal government is not the only place where small businesses can find technology to transfer. Maryland's universities have business offices that coordinate with private industry to develop, evaluate or transfer technology. Maryland businesses benefit from development and evaluation services that are easy to access and which save program development time and expenses.

The federal government itself has created many avenues for technology transfer from its multiple research institutions. Some of the more important are below.

- *The Federal Laboratory Consortium for Technology Transfer*.
- *Individual Technology Transfer Offices*.

[1] https://www.nsf.gov/statistics/2018/nsb20181/report/sections/invention-knowledge-transfer-and-innovation/knowledge-transfer

- *NSF Innovation Corps (I-Corps™)*. To expand access to I-Corps, NSF collaborated with the National Institutes of Health (I-Corps at NIH) in 2014 and the Department of Energy (Energy I-Corps) in 2015.

(1)(iv) explore ways to encourage small businesses to apply for federal SBIR/STTR grants.

The Small Business Innovation Research / Small Business Technology Transfer (SBIR/STTR) programs are designed to help domestic small businesses gain federal support for their Research / Research and Development (R/R&D) efforts. The SBIR and STTR programs each have three phases: Phase I (feasibility and commercial potential); Phase II (technical merit and commercialization); and Phase III (creation of actual products or services). One of the reasons why the SBIR and STTR programs are important to small businesses is to get them through the "valley of death," which represents the time when a business is expending funds to develop new products without deriving income from those products. Without funding to bridge the gap between R&D and product commercialization, a company can fail before it can bring a product to market.

In 2018, Maryland ranked fourth in both the number (247) and total value ($132.9 million) in SBIR awards, after California, Massachusetts, and Virginia. That same year, Maryland ranked ninth in the number of STTR awards received (29 awards) and seventh in STTR funding ($17.2 million). Note that California and Massachusetts are outliers, receiving significantly more SBIR grant awards than other states. Maryland has generally ranked fourth in total SBIR grants received between 2014 and 2018 (except in 2015 when it ranked fifth after Colorado).

Maryland generally attracts more SBIR and STTR investment than would be expected for its population size, attracting 2.6 times the number of SBIR/STTR awards and 2.7 times the amount of funding. The vast majority of the funding awards that Maryland attracts comes from the Departments of Defense and Health & Human Services, which together make up 79 percent of all SBIR and STTR awards and 84 percent of all funding obligations in Maryland.

It should be noted that, on a per capita basis, Massachusetts is by far the most successful state at attracting both SBIR and STTR awards and funding, doing so at almost twice the rate that Maryland does. Massachusetts' success comes from its sheer volume of award applications. For example, companies in Massachusetts received 50% more NIH SBIR awards in 2018 simply because they filed 50% more applications (302 vs. 201). Success rates for each state were roughly the same.

(2) study the laws and regulations of other states governing financial assistance programs for SBIR/STTR grant recipients.

Various states offer financial assistance programs for small businesses pursuing SBIR or STTR funding. Various programs offer assistance for companies in Phase I, Phase II, or Phase III. States also offer assistance to companies in "Phase 0," or the initial proposal-writing and business planning phase of the SBIR/STTR award process. These programs differ from state to state, but most are competitively funded. There are 16 programs in 15 states that offer matching grant programs for SBIR and STTR awardees to help them reach the commercialization stage. States that currently operate supplemental grant programs are listed in detail in the report.

(3) make recommendations regarding financing options for recipients of federal small business innovation research grants and small business technology transfer grants.

Maryland already has many successful programs in place that assist companies in working with the federal government generally, but there is room for improvement in the tech transfer realm. The report's recommendations for improving tech transfer and SBIR/STTR funding are below.

- **Recommendation #1: Coordinate with Congressional Delegation**. Develop and implement a formal process for communicating with Maryland's Congressional delegation on federal issues affecting research and development and the commercialization of technology in Maryland. A formal communication process will provide a means to advocate for an increase in funding for federal research, and raise awareness about barriers to commercializing federally funded research.
- **Recommendation #2: Tech Transfer Portal**. Create a single point of entry for Maryland businesses to take advantage of all of the State's multiple tech transfer assistance and resources. This portal would be web-based and would collect and organize all of the resources listed in the Existing Programs section of this report to ensure that Maryland businesses have the information they need to locate both assistance and transferrable technologies.
- **Recommendation #3: Collaboration with Federal and State Partners**. Collaborate with appropriate partners and service providers in Maryland to create new, or expand existing, programs and events that offer opportunities for Maryland's small businesses to network with federal researchers and clinicians, learn about federal resources for small businesses, discuss regulations for new products and access federal technologies available for licensing.
- **Recommendation #4: SBIR/STTR Commercialization Training and Application Assistance**. Explore creating a State I-CORP program, and SBIR/STTR application assistance program, through a partnership between State agencies and the State's five research universities. A two-stage implementation process is recommended with the first stage being the implementation of the I-CORP training program, and the second stage being the implementation of a SBIR/STTR application assistance program.
- **Recommendation #5: Encourage the Creation of a Statewide Association of Technology Transfer Offices**: Encourage Maryland's institutions to join together and create a Maryland statewide organization of Technology Transfer Offices, based on the model of the national Association of University Technology Managers (AUTM) and the Massachusetts Association of Technology Transfer Offices (MATTO).
- **Recommendation #6: Support and Increase Awareness of Federal Programs and Partnerships.** Support and increase awareness of federal programs that augment the recommendations of this report. This includes :
    - Increasing the awareness and formation of Cooperative Research & Development Agreements between Maryland businesses and federal laboratories;
    - Supporting the creation of Entrepreneurial Leave programs, and Entrepreneur-in-Residence programs by local federal laboratories to develop the business skillsets of scientists commercializing a technology in Maryland; and
    - Increasing the awareness of Strategic Partnership programs, Use Facilities Agreements and Visiting Scientist Programs to increase the utilization of federal laboratory expertise and equipment by Maryland small businesses.

- **<u>Recommendation #7: Examine the Creation of a State SBIR/STTR Matching Grant Program After the Implementation of a State I-Corp Progam and SBIR/STTR Application Assistance Program</u>.** Examine creating a State SBIR/STTR matching grant program that: awards grants competitively and provides preference to applicants who have completed I-Corps training; assists small businesses; requires companies to stay in Maryland for a defined period; allows State funds to be used for expenses not allowed under SBIR grants, such as administrative expenses; and limits grant awards to prevent "SBIR mills."

A detailed discussion of these recommendations is provided on pages 74 through 76 of this report.

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Introduction

Chapter 306 of the Acts of 2019 required the Department of Commerce to:

(1) explore ways to:

> (i) foster job creation and economic development in the State by capitalizing on the federal presence in the State;
>
> (ii) encourage small businesses to engage in federal research and development that has the potential for commercialization;
>
> (iii) facilitate the transfer of technology from small businesses;

(iv) encourage small businesses to apply for federal SBIR/STTR grants; and.

(2) study the laws and regulations of other states governing financial assistance programs for SBIR/STTR grant recipients.

(3) make recommendations regarding financing options for recipients of federal small business innovation research grants and small business technology transfer grants.

In addition to researching state SBIR and STTR programs, and state and federal data, Commerce convened two listening sessions to solicit input on commercializing federally sponsored research in Maryland. Appendix B lists the participants in these listening sessions.

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Existing Programs

There currently are a multitude of State, federal, local and university programs aimed at fostering research and development, and its commercialization, in Maryland. These programs relate directly to the issues raised in Chapter 306 of 2019 as they are designed to:

- assist small businesses with conducting and commercializing research and development; and
- foster the commercialization of research conducted in Maryland by federal agencies and labs, or research and development sponsored by federal agencies.

Understanding these programs that currently exist is helpful in identifying where and how the State may focus its efforts to improve its ability of using federal research to support economic growth. Programs listed in the inventory of existing programs that follows are referenced throughout this report.

Maryland Programs

- *Office of Military and Federal Affairs (OMFA)*: The Maryland Department of Commerce operates the Office of Military and Federal Affairs, which offers assistance to companies who want to contract with the federal government. It also acts as the interface between the Office of Economic Adjustment (OEA) and the State of Maryland. OMFA offers online resources such as a patent database, contracting guides, and operates the Maryland Defense Network portal that assists in matching local businesses with potential federal business opportunities.
    - *Maryland Defense Technology Commercialization Center (DefTech)*: DefTech is an initiative of the Maryland Department of Commerce, funded by the Department of Defense Office of Economic Adjustment and the US Department of Commerce Economic Development Administration through its Regional Innovation Strategies Program and includes twelve partner organizations across the state. It has recently expanded and now has three sites across the State: the original DefTech Center in Havre de Grace; the Frederick Innovative Technology Center in the City of Frederick, and the Howard County Innovation Center in Columbia. DefTech works with entrepreneurs and companies to help them commercialize intellectual property developed by the US Department of Defense. (https://deftechmd.net/)
    - *Maryland Federal Facilities Contracting Guide*: Maryland's Government Contracting Guide, edited by the Maryland Department of Commerce Office of Military and Federal Affairs, provides a comprehensive resource for small business owners as they navigate the complexities of contracting requirements. The Guide offers vital insight to key questions and concerns, includes a list of government acronyms, guidance on the State of Maryland's procurement system, an annotated list of useful websites, examples of successful strategies and information on additional federal and state resources. https://commerce.maryland.gov/Documents/BusinessResource/maryland-federal-facilities-contracting-guide.pdf
    - *Defense Patent Database:* The Maryland Department of Commerce's Office of Military and Federal Affairs (OMFA) also provides businesses with access to the Defense Patent Database, a tool designed to allow businesses to find DoD patents that could be used to support commercialization activities. This database is a joint collaboration between Commerce and the OEA. (https://defpatmd.com/)

- *Maryland Defense Network (MDN)*: The Maryland Department of Commerce's Office of Military and Federal Affairs (OMFA) also provides businesses with the Maryland Defense Network portal, which allows users to make meaningful connections, understand government contracting opportunities, grow business prospects, and assess the overall defense industry impact in the State. MDN is run by a team of technologists, defense industry leaders, military liaisons, economic development organizations, and government officials who actively work to provide support in expanding company portfolios to respond quickly to DoD demands and remain sustainable in a competitive environment. MDN was created through a Defense Industry Adjustment grant offered to the Maryland Department of Commerce by the US Department of Defense, Office of Economic Adjustment. The grant was executed in conjunction with Towson University's Regional Economics Studies Institute and Center for GIS. (https://marylanddefensenetwork.org/)
- *The Maryland Defense Cybersecurity Assistance Program (DCAP)*: This grant program is funded by a grant from the Federal Department of Defense's Office of Economic Adjustment (OEA) through the Maryland Department of Commerce's Office of Military and Federal Affairs. It is coordinated by the Maryland Manufacturing Extension partnership (MD MEP). The DCAP program assists federal defense contractors in complying with the federal regulations necessary to continue providing services to the federal government (NIST 800-171 Standard and DFARS Requirements). Eligible companies must be a Defense Contractor with a physical location in Maryland and have DoD-related business of 10 percent or more OR a DoD contract/procurement request for compliance.

- *The Biotechnology Investment Incentive Credit*: This tax credit is administered by the Department of Commerce and provides an investor with income tax credits equal to 50% of an eligible investment in a Qualified Maryland Biotechnology Company (QMBC), supporting investment in seed and early stage biotech companies. Any investor that does not have Maryland tax liability receives a refund. This program received a $12 million appropriation for FY2020.
- *The Cybersecurity Investment Incentive Tax Credit*: This tax credit is administered by the Department of Commerce and provides a refundable income tax credit to qualified investors who invest in a Qualified Maryland Cybersecurity Company (QMCC). This program received a $2 million appropriation for FY2020.
- *The Research & Development Tax Credit*: This tax credit program is administered by the Department of Commerce and supports businesses that have qualified R&D expenditures in Maryland. There are two state income tax credits, the Basic R&D Tax Credit and the Growth R&D Tax Credit. The Basic credit was funded at $5.5 million for FY2020, while the Growth credit was funded at $6.5 million. Businesses with less than $5 million in gross receipts in Maryland qualify for a refundable credit.
- *Sales and Use Tax Exemption for Purchases for Research and Development:* This sales and use tax exemption is authorized under Section 11-217(a) of the Tax-General Article, and exempts sales and use tax on any purchases by any entity that are intended to be used for basic and applied research in the sciences and engineering and the design, development, and governmentally mandated pre-

market testing of prototypes, products, and processes. This program is administered by the Comptroller.[2]

- *The Employer Security Clearance Costs Tax Credit*: This tax credit is administered by the Department of Commerce and was instituted in 2012 to support businesses who need to employ workers with Federal Security Clearance, but experience long waits to have new employees pass through the clearance process. The tax credit allows businesses to claim up to $200,000 per year for expenses related to obtaining clearance for their workers. In addition, this program allows businesses to claim up to $200,000 per year for up to 50 percent of the expense in setting up a Sensitive Compartmented Information Facility (SCIF), or up to $500,000 for setting up multiple SCIFS. Qualified small businesses can also claim up to $200,000 in credits for rental payments during the first year of a rental agreement for leasing spaces to perform security-based contracting work. This credit is capped at $2 million per year.[3]
- *The Aerospace, Electronic, or Defense Contract Credit*: This tax credit is administered by the Department of Commerce and is available to any business or individual who operates an Aerospace, Electronics, or Defense Contract Tax Credit project within the State. The business entity operating a project must create or retain at least 10,000 qualified positions in Maryland and show at least $25,000,000 in qualifying expenditures in Maryland during the credit year for the project to be certified. A qualified business entity may receive up to three designations. A position is considered qualified if it is located in Maryland, is full-time, of indefinite duration, and has an annual salary of at least $85,000. The maximum credit amount is $2,500,000 per Aerospace, Electronics, or Defense Contract Tax Credit Project.[4]
- *The Maryland Defense Diversification Assistance Program (MDDA)*: This technical assistance program is operated by the Department of Commerce but is not currently accepting new applications. Funding does exist to support currently-enrolled firms. This program assists defense-dependent Maryland businesses in finding new types of revenue streams. The MDDA program provides participating companies the services of expert consultants to create an analysis of their readiness to enter new markets and offers strategies to help lessen their funding dependency on Department of Defense (DoD) revenue. Examples of services provided by these expert consultants include coaching/mentorship, market identification and research, supply chain solutions, strategic development assistance, lean manufacturing, export legal counseling, executive coaching, ITAR/EAR Compliance, logistics and distribution services, website globalization, marketing assistance and more.
- *TEDCO.* The Technology Development Corporation (TEDCO) was created by the Maryland State Legislature in 1998 to facilitate the transfer and commercialization of technology from Maryland's research universities and federal labs into the marketplace and to assist in the creation and growth of technology-based businesses in all regions of the State. TEDCO is an independent organization that strives to be Maryland's lead source for entrepreneurial business assistance and seed funding for the development of startup companies in Maryland's innovation economy. TEDCO is a resource of mentoring, funding and networking for entrepreneurs and start-ups that need guidance as they bring innovative concepts to market. TEDO operates multiple programs that assist companies with technology transfer:

[2] https://dbm.maryland.gov/budget/Documents/operbudget/FY2020TaxExpenditureReport.pdf
[3] https://commerce.maryland.gov/fund/programs-for-businesses/employer-security-clearance-costs-tax-credit
[4] https://taxes.marylandtaxes.gov/Resource_Library/Tax_Publications/Business_Tax_Credits/Aerospace_Electronics_or_Defense_Contract_Tax_Credit.shtml

- *TEDCO Federal and State Technology (FAST) Partnership Program:* TEDCO has received one of 24 national awards for $125,000 in both FY 2018 and FY 2019 from the U.S. Small Business Administration to fund outreach for the SBIR / STTR programs under the Federal and State Technology (FAST) Partnership Program. TEDCO has used this funding, along with its own matching funds, to team with the GovCon Incubator and the Small Business Development Center (SBDC) to create the Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Proposal Lab. The Lab is a series of workshops intended to work with Women Owned, Small Disadvantaged, and Rural Maryland businesses who are first time SBIR/STTR proposal submitters. The SBA's goal is to double the national win rate for first time proposals from 16% to 32%.[5]
- *N-STEP*. N-STEP (NIST – Science and Technology Entrepreneurship Program) provides opportunities for motivated researchers to build upon the experience gained while working at NIST as they explore entrepreneurial careers. N-STEP focuses on commercialization of NIST research by NIST researchers, who are interested in forming companies to independently pursue further translational research and development of technologies. N-STEP offers grants of up to $112,000 to support projects that continue or initiate translational research and development activities specifically related to NIST's mission, so that the technologies can be commercialized as products or services to benefit the public.
- *Maryland Innovation Initiative*. The Maryland Innovation Initiative (MII) was created as a partnership between the State of Maryland and five Maryland academic research institutions (Johns Hopkins University, Morgan State University, University of Maryland College Park, University of Maryland Baltimore and University of Maryland Baltimore County.) The program is designed to promote commercialization of research conducted in the partnership universities and leverage each institution's strengths. The Innovation Commercialization Program was created to foster the transition of promising technologies having significant commercial potential from Qualifying Universities, where they were discovered, to the commercial sector, where they can be developed into products and services that meet identified market needs. MII funds up to $265,000 through two phases of the program.
- *Maryland Stem Cell Research Fund*. Maryland Stem Cell Research Fund (MSCRF) was established by the governor and the Maryland General Assembly under the Maryland Stem Cell Research Act of 2006. The purpose of the fund is to promote state-funded human stem cell research and medical treatments through grants to public and private entities in the state.
- *Maryland Venture Fund*. The Maryland Venture Fund is an early-stage, evergreen venture capital fund dedicated to funding and growing the next generation of outstanding businesses in Maryland. We are an experienced team with significant operating and venture experience whose focus is on making the entrepreneurs successful. With more than $100M in assets under management, we partner with exceptional entrepreneurs and help them build valuable companies that last. We do not generalize what industries we invest in, but rather buy into our entrepreneurs' vision.

[5] https://www.tedcomd.com/sites/default/files/2019-11/Annual%20Report-Fiscal%20Year%202019.pdf

    - *TEDCO Seed Investment Fund*: This program is administered by TEDCO and supports small, seed-stage, for-profit Maryland companies in their effort to develop and commercialize new technology-based products.
- *The Maryland Manufacturing Extension Partnership:* "The Maryland Manufacturing Extension Partnership (MD MEP) is a non-profit organization funded by NIST, industry, and the State of Maryland that is focused on growing and strengthening Maryland manufacturers. Serving mostly small- and mid-size manufacturers (500 employees or less) across all industries, MD MEP provides an array of programs and services to help these local companies operate more efficiently, grow profitability and create more jobs and opportunities in Maryland. MD MEP is part of the MEP National Network™ and has served more than 400 manufacturers across the state, generating more than $217 million in economic impact and more than 900 jobs . . . The MEP National Network™ comprises the National Institute of Standards and Technology's Manufacturing Extension Partnership (NIST MEP), the 51 MEP Centers located in all 50 states and Puerto Rico, and over 1,300 trusted advisors and experts at more than 400 MEP service locations, providing any U.S. manufacturer with access to resources they need to succeed."[6]
- *Maryland Procurement Technical Assistance Center (MD PTAC)*: The Maryland Procurement Technical Assistance Center is a program funded in part through a cooperative agreement with the Defense Logistics Agency (DLA). It was founded in 2002 in an effort to assist the DLA's Procurement Technical Assistance Program in expanding the number of businesses capable of participating in government contracting. MD PTAC does this by providing businesses with an understanding of the requirements of government contracting and the market know-how they need to obtain and successfully perform federal, state, and local government contracts and by supporting government agencies in reaching and working with the suppliers they need. (https://www.mdptac.org/)

Federal Resources

Federal Facilities

- 12 Major Military Installations
- More than 50 non-military federal facilities
- 70 Federal Research Facilities
- 4 Federally Funded Research and Development Centers
- 2 Federally Designated University Affiliated Research Centers (Johns Hopkins and the University of Maryland College Park)

Federal Programs and Statues

- *Federal Research and Development Tax Credit:* Allows businesses to deduct expenses paid or incurred for qualified research.
- *Bahy-Dole Act of 1980:* Allows federally sponsored researchers to maintain control of their inventions if the federal government elected not retain ownership of an invention developed with federal funds.

[6] http://www.mdmep.org/about-us/

- *Stevenson-Wydler Technology Innovation Act of 1980:* Allows federal laboratories to enter into Cooperative Research and Development Agreements (CRADAs) to facilitate technology transfers.
- *Federal Technology Transfer Act of 1986:* Amended the Stevenson-Wydler Act to allow government inventors to patent their technology and receive a portion of royalties when their patents are licensed.
- *Small Business Innovation Research Grants (SBIR):* Established in 1982, federal agencies are required to use a portion of their budget to provide grants to small businesses conducting research related to an agencies' mission.
- *Executive Order 12591 (1987):* Allows federal laboratories to grant contractors the title of patents developed in whole or in part with federal funds, as long as the government is given a royalty-free license for use.
- *Omnibus Trade and Competitiveness Act of 1988:* Created the Hollis Manufacturing Extension Partnership Program that provides assistance to small and medium-sized manufacturers (SMMs) to improve production processes, upgrade technological capabilities, and facilitate product innovation.
- *Small Business Technology Transfer Program (STTR):* Established in 1992, and patterned after the SBIR program. STTR requires small businesses to partner with non-profit research institutions, which are typically universities or federal laboratories, to transfer technology from non-profit research institutions to small businesses and ultimately to the market place.
- *Entrepreneurial Leave Programs:* Allows personnel at federal labs to take "entrepreneurial leave" to focus on commercializing technology developed at a federal lab.
- *Entrepreneur-in-Residence (EIF) Programs*: Allows entrepreneurs from outside of the government who are interested in using their skills for the public good to conduct research at federal agencies and labs.
- *Public-Private Entrepreneurial Partnerships*: Partnerships between federal laboratories and the private sector that allow for the placement of personnel at federal labs to advance technology research until it can succeed beyond the lab.
- *Strategic Partnership Program*: Allows a federal laboratory to advise a U.S. company or researcher on problems for which a laboratory has special expertise or equipment.
- *Use of Facilities Agreements:* Allows non-government researchers and parties (universities, incubators, private companies) to use specialized equipment, specialized rooms, testing centers, or unique experimental property of federal laboratories.
- *Visiting Scientist Program:* Allows personnel from private industry to work for a limited period of time in a federal lab.
- *Educational Partnership Agreements (EPAs):* Agreements between the Department of Defense (DoD) and educational institutions to encourage and enhance the study of scientific disciplines.
- *Dual-Use Technology Transfers:* Technology development processes and programs that focus on dual-use technology applications by the government and the commercial market.
- *The Federal Laboratories Consortium for Technology Transfer (FLC):* Created in 1974, FLC provides assistance with identifying federal technologies that may be licensed or federal laboratories with which a researcher or company may partner to develop technology.
- *Federal Technology Transfer Offices:* Each federal laboratory, as well as many federal agencies, operate their own technology transfer offices.

- *Innovation Corps (I-Corps):* Run by the National Science Foundation, I-Corps provides researchers and inventors instruction on how to commercialize their technologies.
- *Federal and State Technology (FAST) Partnership Program:* Funded by the U.S. Small Business Administration, the FAST program provides one year funding to organizations to execute state or regional programs to increase the number of SBIR/STTR proposals.
- *Growth Accelerator Fund:* Funded by the U.S. Small Business Administration, the Growth Accelerator Fund provides $50,000 grants to 60 of the nation's most innovative and promising small business accelerators and incubators.
- *Small Business Development Center (SBDCs):* SBDCs are partnerships between the Small Business Administration and local partners, often universities, to facilitate the creation and growth of small businesses.
- *Procurement Technical Assistance Center (PTAC):* PTACs provide local, in-person counseling and training to small business owners who want to sell to local, state, or federal governments.
- *Regional Innovation Clusters (RICs):* Administered by the U.S. Small Business Administration, RICs promotes and supports industry clusters of interconnected businesses, suppliers, service providers, and related institutions in a particular industry or field.
- *Regional Innovation Strategies (RIS) Program:* Operated by the Office of Innovation and Entrepreneurship, the RIS program awards grants that build regional capacity to build innovations in to jobs through: (1) proof-of-concept and commercialization assistance to innovators and entrepreneurs; and (2) operational support for organizations that provide essential early-stage risk capital to innovators and entrepreneurs.

University Technology Transfer Programs

- USM Institute for Bioscience and Biotechnology Research
- Maryland Technology Enterprise Institute at College Park
- Fraunhofer Center for Experimental Software Engineering at UMD
- UMBC Center for Cybersecurity
- Johns Hopkins University Information Security Institute
- Johns Hopkins University Technology Ventures
- University of Maryland School of Medicine Center for Vaccine Development

University organizations dedicated to tech transfer and commercialization:

- *University of Maryland System.*
    - *Maryland Technology Internship Program (MTIP)*: This program is administered by UMBC and funded by the State of Maryland, and is designed to help Maryland retain top talent by offering financial assistance to technology-based businesses, as well as state and local agencies, to hire interns.
    - *UM Maryland Industrial Partnerships (MIPS) Program*: This tech transfer program is administered by the University System of Maryland (USM) and provides funding, matched by participating companies, for university-based research projects that help companies develop new products.
    - *MPower:* The University of Maryland Strategic Partnership: MPowering the State (MPower) is a collaboration between the University of Maryland, Baltimore (UMB) and

the University of Maryland, College Park (UMCP). MPower was created by the University of Maryland Strategic Partnership Act of 2016, which strengthened and formalized the structured relationship between UMB and UMCP that was begun in 2012. The law deepens the alliance and energizes UMB and UMCP to pursue even greater transformative change and impact, far surpassing what each institution could do independent of each other. Part of the MPower partnership was the creation of UM Ventures, which joined together the Offices of Technology Transfer and Commercialization at UMCP and UMB to provide "unified licensing and patenting services and joint marketing to the business community to increase efficiency and productivity . . . UM Ventures has laid out the following priorities:

- Strengthen and integrate the tech transfer offices at UMB and UMCP
- Promote activities and successes of the UM Ventures effort
- Create a single point of entry for business
- Streamline processes to enhance tech transfer and industry collaboration
- Develop a cohesive plan to nurture startup companies
- Create an industry liaison office in Montgomery County"

Johns Hopkins University Technology Ventures. Johns Hopkins University Technology Ventures (JHTV) was founded in 2014 after a 2013 study (*Report of the Committee on the Innovation Ecosystem*) found that the University needed to do more to support innovation within itself and in the wider economy. JHTV's stated mission is to "maximize the impact of Johns Hopkins University's research excellence by facilitating the translation and commercialization of discoveries into accessible technologies, products and services that benefit society."[7] To accomplish this JHVU has set up multiple programs and services, including:

- FastForward, a "coordinated suite of resources designed to efficiently move technologies from startup to marketplace;"
- FastForward U, which "provides training and resources to empower emerging student entrepreneurs to develop ideas and disruptive technologies into successful startups;" and
- Commercialization Academy, which "provides experiential learning opportunities to select graduate and undergraduate students interested in the commercial assessment and marketing of Johns Hopkins technologies."[8]

[7] https://ventures.jhu.edu/
[8] https://ventures.jhu.edu/programs-services/

(1)(i) Explore ways to foster job creation and economic development in the State by capitalizing on the federal presence in the State

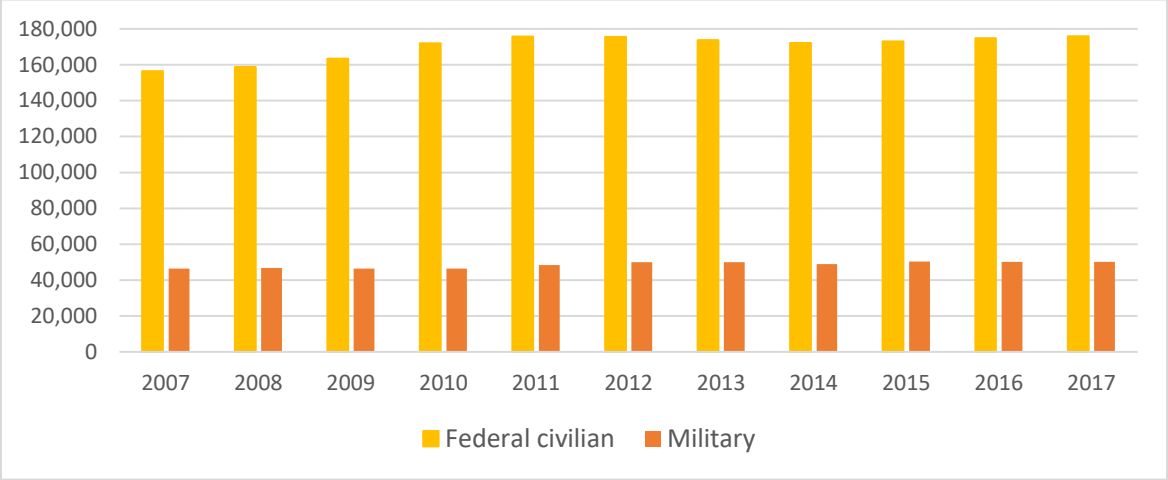
Maryland ranks highly in almost all metrics relating to federal investment and employment within the State. Due to the long history of federal employment and investment in Maryland, the State has already developed programs that assist local businesses in capitalizing on local federal investments.

The Federal Presence in Maryland

Federal employees are an important component of the Maryland economy, earning $17.9 billion dollars in income, 10.4 percent of all wage and salary compensation in the State. An even larger number of federal employees reside in Maryland, comprising 10 percent of all employed residents. These resident workers reported earning $28.8 billion in income in 2017, and almost 40 percent of them commuted to other states to work.

Federal Civilian Jobs in Maryland. In 2017 (the most recent data available), the U.S. Bureau of Economic Analysis estimated that there were 175,887 federal civilian jobs in Maryland. In 2017, DoD Defense Manpower Data Center reported that there were 28,888 active duty service members stationed in Maryland, and 18,596 reservists. Civilian federal employment has been above 170,000 since 2010, up from 156,690 in 2007.

Figure 1: Maryland Federal Civilian and Military Employment, Full & Part-Time, 2007-2017



Source: U.S. Bureau of Economic Analysis, Table SA27.

Notes: Military employment includes both active-duty service members and Reserve members. Civilian DoD employment is included in the federal civilian category. BEA estimates the number of employees involved in classified activities and adds it to the civilian total, as this data is not reported.

Per capita, Maryland has more federal civilian jobs than any other State. Numerically, Maryland ranks fifth, behind only California, Virginia, Texas, and the District of Columbia. Percentage-wise, Maryland consistently ranks second after the District of Columbia in the percentage of wage and salary employees employed by the federal government (6.2 percent in 2017).

Federal Civilian Employment in Maryland by Agency. The Office of Personnel Management (OPM) tracks federal civilian employment for workers who are part of the federal retirement system. In June 2018 there were 129,234 federal civilian employees tracked by OPM. The largest executive department in Maryland by employment is the Department of Health and Human Services, which employs 39,791 people, or 30.8 percent of all federal employees who work in the State. The largest 20 OPM-tracked federal civilian employers in Maryland are listed below. In total, these 20 employers represent 74.8 percent of all OPM-tracked federal civilian employment in Maryland.

Figure 2: Largest 20 OPM-Tracked Federal Civilian Employers in Maryland, June 2018

Office	Employment	Percentage
National Institutes Of Health (DHHS)	17,179	13.3%
Food And Drug Administration (DHHS)	13,988	10.8%
Social Security Administration (Independent)	10,539	8.2%
Naval Air Systems Command (DoD)	8,866	6.9%
U.S. Census Bureau (Commerce)	4,606	3.6%
Centers For Medicare & Medicaid Services (DHHS)	4,446	3.4%
U.S. Army Research, Development And Engineering Command (DoD)	4,077	3.2%
Veterans Health Administration (VA)	4,049	3.1%
Internal Revenue Service (Treasury)	4,002	3.1%
Naval Sea Systems Command (DoD)	3,335	2.6%
National Oceanic And Atmospheric Administration (Commerce)	2,997	2.3%
Goddard Space Flight Center (NASA)	2,831	2.2%
National Institute Of Standards And Technology (NIST) (Commerce)	2,804	2.2%
U.S. Army Medical Command (DoD)	2,575	2.0%
Defense Information Systems Agency (DoD)	2,469	1.9%
Military Treatment Facilities Under DHA (DoD)	2,295	1.8%
Nuclear Regulatory Commission (Independent)	2,045	1.6%
U.S. Army Communications Electronics Command (DoD)	1,894	1.5%
Health Resources And Services Administration (DHHS)	1,661	1.3%
All Agencies Tracked by OPM	129,234	

Source: FedScope, accessed 1/3/20192019 – this data does not include US Post Office employees and classified employees (NSA and other clandestine agencies)

Federal Employees Residing in Maryland. An even larger number of federal employees reside in Maryland. An analysis of Census data finds that 295,021 full-time civilian workers residing in Maryland reported worked for the federal government in 2017, almost 1 out of every 10 employed civilian Maryland residents. These resident workers reported earning $28.8 billion in income in 2017. Almost 40 percent of these resident workers reported commuting to other states for their employment. Federal employees who reside in Maryland are concentrated mostly in Montgomery, Prince George's, Baltimore, and Frederick counties, along with Baltimore City. This same data set shows that, while most civilian federal workers who live in Maryland also work in Maryland, about 30 percent commute into Washington, D.C., and a smaller but still significant number commute into other neighboring states.

Figure 3: Workplace of Federal Civilian Employees Residing in Maryland, 2017

Workplace State	Civilian Workers	Percentage
Maryland	181,500	61.5%
Washington, D.C.	85,299	28.9%
Virginia	21,879	7.4%
Pennsylvania	646	0.2%
West Virginia	612	0.2%
Delaware	412	0.1%
Other	4,673	1.6%
Total	295,021	100.0%

Source: Public Use Microdata, 2017 American Community Survey

Civilian Federal Facilities. Maryland is home to more than 50 non-military federal facilities. Research activities spilling from many of these facilities fuels the increasingly dynamic growth of Maryland companies in a wide variety of industries, offering the potential for collaborative relationships and market opportunities for local firms. The following table contains a list of the most significant federal facilities in the state.

Figure 4: Major Non-Military Federal Facilities in Maryland

Department / Facility	County	Employment
Agriculture / Beltsville Agricultural Research Center	Prince George's	1,000
Commerce / Census Bureau	Prince George's	4,540
Commerce / National Institute of Standards and Technology	Montgomery	2,000
Commerce / National Oceanic and Atmospheric Administration	Montgomery	2,910
Energy / Germantown Facility	Montgomery	1,040
Health and Human Services / Centers for Medicare and Medicaid Services	Baltimore	3,600
Health and Human Services / Food and Drug Administration	Montgomery	8,500
Health and Human Services / National Institutes of Health	Montgomery	17,535
Treasury / Internal Revenue Service	Prince George's	4,350
NASA / Goddard Space Flight Center	Prince George's	3,000
National Security Agency and Central Security Service	Anne Arundel	*
Nuclear Regulatory Commission	Montgomery	2,520
Social Security Administration	Baltimore County	12,000

* Employment for the National Security Agency is included with Fort Meade; see Military Installations table below.
Source: Maryland Department of Commerce, 2017.

Military Facilities. The list below provides an overview of Maryland's major federal military installations. Personnel estimates include military and civilian employees but exclude contractors to the extent possible.

Figure 5: Major Federal Military Installations in Maryland

Installation	County	Employment
Aberdeen Proving Ground	Harford	21,000
U.S. Army Forest Glen Annex	Montgomery	NA
U.S. Army Research Laboratory – Adelphi Laboratory Center	Prince George's	1,235
U.S. Coast Guard Yard	Anne Arundel	1,010
Fort Detrick	Frederick	6,400
Fort George G. Meade*	Anne Arundel	54,000
Joint Base Andrews Naval Air Facility Washington	Prince George's	17,500
U.S. Naval Academy / Naval Support Activity, Annapolis	Anne Arundel	2,340
Naval Air Station Patuxent River	St. Mary's	11,725
Naval Support Activity Bethesda / Walter Reed National Military Medical Center	Montgomery	12,000
Naval Support Facility Indian Head	Charles	2,945
Naval Surface Warfare Center – Carderock Division	Montgomery	1,580

NA – Not available.

* Employment data at Fort Meade is estimated. No official data is available.

Note: Employee counts exclude contractors to the extent possible; embedded contractors may be included.

Source: Maryland Department of Commerce, 2017.

Federal Contract Spending in Maryland. In FY2019, over $33 billion in federal contract work was performed in Maryland, according to FPDS, ranking it fourth in total contract place-of-performance spending that fiscal year, and third in per-capita spending (at $5,395 per person). Maryland has held these rankings consistently for at least the last five fiscal years. The top 10 states by total contract spending can be found in Figure 6.

Figure 6: Federal Contract Spending Rank by Principal Place of Performance State, FY2019

Principal Place of Performance State	Total Contract Spending Rank	Per Capita Rank
California	1	18
Virginia	2	2
Texas	3	16
Maryland	4	3
District of Columbia	5	1
Florida	6	24
Pennsylvania	7	21
Connecticut	8	5
Massachusetts	9	11
Missouri	10	9

Source: FPDS, 2019

Federal Grant Spending in Maryland. In FY2019, over $15 billion in federal grants were awarded to recipients in Maryland, according to USASpending, ranking it 17th in total grant awards that fiscal year, and 22nd in per-capita spending (at $2,540 per person). As grant funding levels are often related to

population levels, Maryland's rankings in this area are not surprising. Note that SBIR / STTR funding is included in this category of spending, and will be discussed in detail in a later section.

Federal Research Laboratories in Maryland

More than a dozen federal agencies conduct R&D work in over 70 research centers in Maryland. In addition to NIH, some of the federal government facilities performing R&D in Maryland are:

- Department of Agriculture – Beltsville Agricultural Research Center (BARC)
- Environmental Protection Agency (EPA)
- Food and Drug Administration (FDA)
- NASA Goddard Space Flight Center
- National Institute of Standards and Technology (NIST)
- National Oceanic and Atmospheric Administration (NOAA)
- National Security Agency (NSA)
- U.S. Geological Survey (USGS)

Federal R&D comprises important work being done at the state's military installations. Military research facilities in Maryland include:

- Armed Forces Radiobiology Research Institute
- Army Center for Environmental Health Research
- Army Edgewood Research, Development and Engineering Command
- Army Medical Research Institute of Infectious Diseases
- Army Research Laboratory
- National Biodefense Analysis and Countermeasures Center
- National Interagency Confederation for Biological Research
- Naval Medical Research Center
- Naval Surface Warfare Center
- Naval Air Warfare Center, Aircraft Division

An important engine of R&D in Maryland and the U.S., the National Institutes of Health (NIH) in Bethesda employs approximately 17,000 including scientists, doctors, technicians and administrators. These individuals conduct research primarily in medical fields, but also in bioscience, computer science, and engineering.

A full list of Maryland's federal research laboratories can be found in Appendix D.

Research in Maryland

Maryland is a national leader in federally sponsored research, and total research and development spending. In 2018, according to the National Science Board, Maryland ranked:

- 5th in total research and development spending;
- 4th in higher education research and development;
- 2nd in research and development intensity (measured as research and development spending as a percentage of state GDP); and
- 1st in federally sponsored research and development.

Johns Hopkins University has been the national leader in university sponsored research for the past thirty-nine years. In 2018, Johns Hopkins spent a record $2.56 billion on research, which was over $1.0 billion more than the university ranked second, the University of Michigan at Ann Arbor.

Total Research Expenditures in Maryland. As reported by the National Science Foundation, total research expenditures in Maryland in 2016 were $21.7 billion, ranking it 7th out of the 50 states plus D.C. However, when state population is taken into account, Maryland ranks third per capita in total R&D spending obligations after the District of Columbia (1) and Massachusetts (2). Maryland also ranks third in *R&D Intensity*, or the ratio between total R&D spending obligations and total State GDP, after New Mexico (1) and Massachusetts (2). Maryland ranks third in the share of total R&D expenditures expended by the federal research sector (54.5%), but ranks 47th in the share of total R&D expended by businesses (26.1%). In 2016, all of Maryland's research sectors received a total of $17 billion in federal funding for research. This represented almost 79 percent of the total funds expended in Maryland on research and development. For comparison purposes, the national average is only 23 percent. See Appendix E for more detailed information.

Federal Laboratory Expenditures in Maryland. Federal and academic institutes and research centers in Maryland expended some $11.8 billion on research and development activities in 2016. This massive, on-going research effort occurs at more than 350 locations of federal and academic research centers in the state. Over $11 billion of these expenditures took place at Maryland's 70 plus federal laboratories, which is referred to as *intramural spending*. Maryland's level of intramural research expenditures significantly eclipses all other states, being five times the amount of Virginia (2) and Alabama (3). In fact, Maryland alone was responsible for 35 percent of the Nation's total federal intramural research expenditures in 2016.

FFRDCs in Maryland. Maryland is home to four of the Nation's 42 Federally Funded Research and Development Centers. These four centers are listed in Figure 7 below. In total, these FFRDCs reported spending $830 million on research and development activities in 2016.

Figure 7: Maryland's Federally Funded Research and Development Centers, 2016

FFRDC	Type	Sponsor	Location	2016 Total Expenditures*
CMS Alliance to Modernize Healthcare	Non-Profit	HHS, CMS	Baltimore, MD	$141,860
National Biodefense Analysis and Countermeasures Center	Non-Profit	DHS, S&T	Frederick, MD	$32,902
National Cybersecurity Center of Excellence	Non-Profit	NIST	Rockville, MD	$13,076
Frederick National Laboratory for Cancer Research	Industry	HHS, NIH	Frederick, MD	$642,165

* Includes non-research expenditures and expenditures for research activities obligated in prior fiscal years

UARCs in Maryland. Maryland is home to two University Affiliated Research Centers: The Johns Hopkins University's Applied Physics Laboratory (APL) and the University of Maryland, College Park's Applied Research Laboratory for Intelligence and Security (ARLIS), which was known until 2018 as the Center for Advanced Study of Language (CASL). APL is sponsored by the Department of the Navy, while ARLIS is

sponsored by the Office of the Secretary of Defense. APL reports employment of 6,700 persons, 79 percent of whom are "technical professional",[9] while ARLIS does not report employment numbers. APL reported revenue from contracts and grants in 2018 of $1.52 billion.

Academic Research Expenditures. Four major academic institutions—the University of Maryland College Park, the University of Maryland, Baltimore, the University of Maryland, Baltimore County and the Johns Hopkins Institutions—have created more than 250 research centers in science and technology. Some of these centers are operated in conjunction with federal agencies, state government, major universities around the U.S., and non-profit R&D foundations. Maryland higher education institutions collectively performed $3.8 billion of research and development in 2016, ranking it fifth in this category out of the 50 states plus the District of Columbia, after California (1), New York (2), Texas (3), and Pennsylvania (4).

Business Research Expenditures. Maryland lags behind other top research states in the amount of R&D expenditures by private business. While Maryland's business R&D expenditures increased over $1.6 billion between 2012 and 2016, by 2016 it only ranked 19th in this category. However, Maryland businesses receive 33.1 percent of all their reported research expenditures from the federal government ($1,877 million in 2016), ranking the State third in federal support for business research (see Figure 36).

An important trend to note is the concentration of business funding into fewer and fewer states. NSF data from 2017 shows that over half of all business R&D spending in 2017 was concentrated in only five states: California, Massachusetts, Michigan, Washington and Texas. Spending in these five states increased from 49.4 percent of total business R&D in 2012 to 55.2 in 2017. In addition, thirteen states saw "real dollar declines between 2016 and 2017."[10]

Maryland Support. Because of the high integration between federal government activities and Maryland's economy, the State of Maryland has instituted programs to support Maryland businesses in their efforts to work with federal agencies.

Programs directly aimed at assisting Maryland businesses in securing federal contracts or business include the: Employer Security Clearance Costs Tax Credit; Aerospace, Electronic, or Defense Contract Credit; Maryland Defense Cybersecurity Assistance Program (DCAP); Office of Military and Federal Affairs (OMFA); Maryland Procurement Technical Assistance Center; Maryland DefTech Center; and OMFA's government contracting guide. Discussion of these programs is provided on pages thirteen through sixteen of this report.

Other programs administered by the Department of Commerce that can assist businesses that receive federal contracts or grants but are not specifically oriented to obtaining federal support are the: Biotechnology Investment Incentive Credit; Cybersecurity Investment Incentive Tax Credit; Research and Development Tax Credit; Maryland Technology Internship Program (MTIP); TEDCO Seed Investment Fund; and UM Maryland Industrial Partnerships (MIPS) Program. Discussion of these programs is provided in the Existing Programs section of this report.

[9] https://www.jhuapl.edu/About

[10] https://ssti.org/blog/useful-stats-business-rd-growing-more-concentrated-fewer-states

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(1)(ii) Explore ways to encourage small businesses to engage in federal research and development that has the potential for commercialization

To understand how best to encourage small businesses to engage in federal research and development, it is necessary to understand the landscape of small businesses in Maryland and their current involvement in R&D activities. It is also necessary to understand the general trends affecting small business research spending over time, and how recent changes in federal law and regulation may make it easier for small businesses to receive support for their research efforts and have their work recognized in official statistics.

Small Business in Maryland. Like the rest of the nation, the vast majority of firms in Maryland are small businesses. In total, there were over 143 thousand private-sector firms in Maryland in the first quarter of 2018, employing over 2.1 million workers. Of these, almost 94 thousand employed fewer than 5 people each (65.6%) and employed a total of 130,000 workers. Only 453 firms employed more than 500 people in 2018, and these employed over 600 thousand workers. While there are different definitions of what constitutes a small business, firms employing fewer than 50 people made up over 95 percent of all firms and employed over 730 thousand workers. Using the size definitions used in the *Business R&D and Innovation Survey* (BRDIS) discussed below, fully 80 percent of all firms in Maryland are "micro" businesses employing fewer than 10 employees. An additional 16 percent are small businesses employing 10 to 49 employees.

Figure 8: Number of Firms by Size Range and Supersector, First Quarter 2019

Supersector	Micro	Small	Medium	Large	Total
Natural Resources and Mining	S	S	S	S	685
Construction	12,709	2,714	543	46	16,012
Manufacturing	2,341	854	293	79	3,567
Trade, Transportation, and Utilities	20,055	3,749	946	231	24,981
Information	1,987	286	107	16	2,396
Financial Activities	8,812	1,187	349	76	10,424
Professional and Business Services	31,908	5,061	1,222	218	38,409
Education and Health Services	11,596	3,297	935	243	16,071
Leisure and Hospitality	7,447	3,763	814	111	12,135
Other Services	S	S	S	S	18,461
Total, All industries	113,915	22,787	5,404	1,035	143,141

Source: Commerce analysis of Quarterly Census of Employment and Wages data from the Maryland Department of Labor, 2019

Federal Small Business Research Data. According to the joint Census Bureau-NSF *Business R&D and Innovation Survey* (BRDIS), U.S. companies performed nearly $356 billion in R&D in 2015. Most of this activity (88%) took place in large companies (those with 250 or more employees). Small companies with only 5 to 49 employees accounted for just 5% of R&D spending, while medium-sized companies of between 50 and 249 employees accounted for the remaining 7%.[11] While small businesses in total were

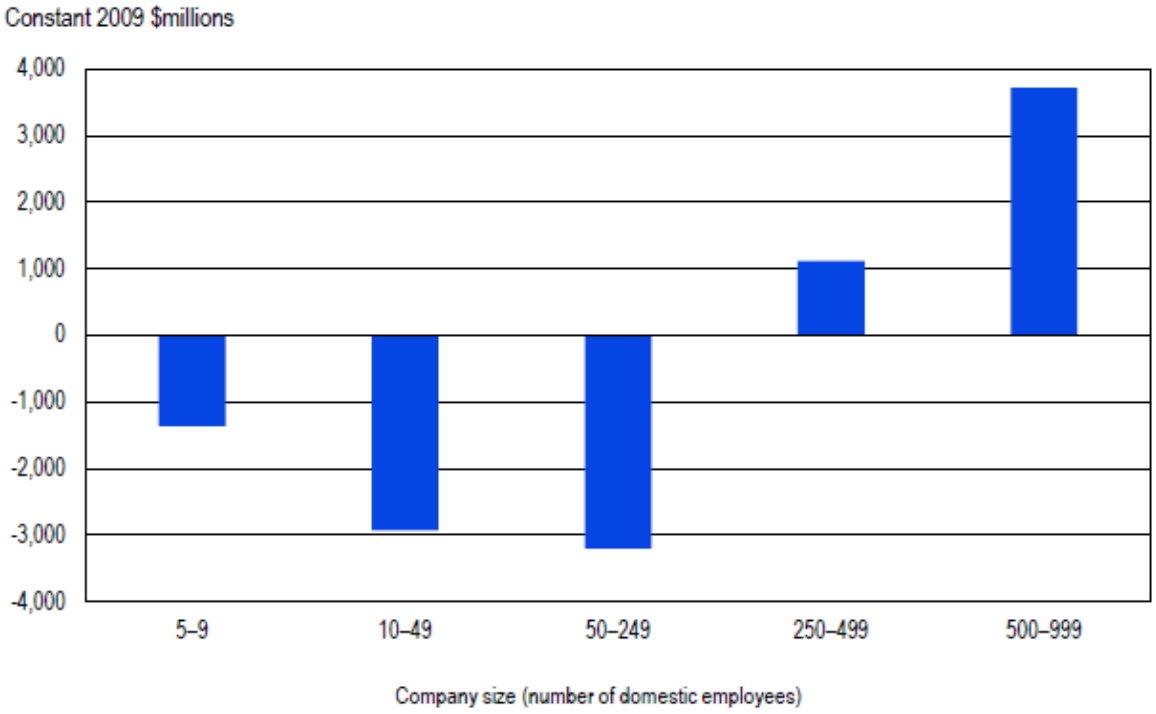
[11] https://www.nsf.gov/statistics/2019/nsf19316/

responsible for $18.9 billion in R&D expenditures in 2015, “micro” companies of just five to nine employees were responsible for only $3 billion, or just 0.8 percent of all R&D in the nation that year.[12]

The recent recession saw reductions in total R&D spending in the United States of almost 6 percent in constant dollars between 2009 and 2011, and total R&D spending in constant dollars did not regain its 2009 level until 2013. R&D spending continued its upward climb and, by 2015, had surpassed 2009 constant dollar spending by 10 percent. However, the pattern of R&D spending has changed.

Between 2009 and 2015, after adjusting for inflation, BRDIS data shows that small businesses employing fewer than 250 people performed significantly less R&D in 2015 than they did in 2009. Large companies employing between 250 and 499 workers saw a small increase, but the largest increase came from companies employing 500 or more workers. This trend stands “in stark contrast to the 2003–07 trends,” which “showed small firms had higher growth rates in R&D performance than larger companies and an increasing share of business R&D performance.”[13] (See Figure 9) Clearly, the recession had an effect on the ability of small businesses to perform research, but had less or no effect on large firms.

Figure 9: Change in domestic R&D performance between 2009 and 2015, by selected company size



Source: National Science Foundation, National Center for Science and Engineering Statistics, Business R&D and Innovation Survey, https://www.nsf.gov/statistics/2019/nsf19316/

[12] Ibid.

[13] https://www.nsf.gov/statistics/2019/nsf19316/

Small Business and the Federal R&D Tax Credit. In 1981, Congress passed the Economic Recovery Tax Act of 1981 (ERTA), which contained the 'Credit for Increasing Research Activities,' commonly known as the Federal Research and Development Tax Credit. This tax credit allows businesses to deduct "expenses paid or incurred for qualified research."[14]

When Congress found that small businesses had problems taking advantage of the federal R&D Tax Credit, it passed the Protecting Americans from Tax Hikes (PATH) Act of 2015. In addition to making the R&D tax Credit permanent, two alternative methods for improving small business' access to the credit were created. One eliminated "the Alternative Minimum Tax bar, allowing businesses with $50 million or less in gross receipts to take advantage of the incentive."[15] The other allows small businesses with "gross receipts of less than $5 million for the tax year, and no gross receipts for any tax year before the 5-tax-year period ending with the tax year" to offset up to $250,000 in R&D expenses against their social security payroll tax.

Due to the structure of the tax credits, many taxpayers, especially partnerships and S corporations, do not claim the tax credit. The Alternative Minimum Tax for small business (filed on form 8794) is too new for the IRS to publish statistics. However, the IRS does publish data collected on Form 6765 on the national level for C-corporations only. Data for sole proprietorships or limited-liability S-Corporations is not included. However, reviewing claimed R&D tax credits from C-corporations in 2013 (the latest data available from the IRS) shows that there is a strong link to company size and participation in research and development activities. As Figure 10 shows, a tiny percentage of companies who reported business receipts of less than $5 million claimed the R&D tax credit. Once business receipts climb above $5 million, the percentage of claiming companies starts to go up substantially. Very large companies are most likely to claim R&D credits, as over 29 percent of companies reporting $250 million or more in business receipts claimed the credit in 2013.

Figure 10: Federal R&D Research Credit Claimed by Size of Business Receipts, 2013

Size of Business Receipts	Total Returns of Active Corporations	Corporations Claiming R&D Research Credit	Claiming Percentage
Total, All Corporations	5,887,804	16,624	0.3%
Receipts under $1,000,000	4,785,015	4,499	0.1%
$1,000,000 under $2,500,000	556,975	1,417	0.3%
$2,500,000 under $5,000,000	240,712	1,483	0.6%
$5,000,000 under $10,000,000	139,200	1,376	1.0%
$10,000,000 under $50,000,000	129,787	3,469	2.7%
$50,000,000 under $100,000,000	17,612	1,003	5.7%
$100,000,000 under $250,000,000	10,544	1,063	10.1%
$250,000,000 or more	7,960	2,314	29.1%

Source: Internal Revenue Service, SOI Tax Statistics, 2019

[14] https://www.irs.gov/instructions/i6765

[15] https://www.forbes.com/sites/deanzerbe/2019/04/26/rd-tax-credit-still-the-one-for-small-and-medium-business-owners/#5ab47ca12910

By major industry sector in 2013, the Manufacturing sector filed the largest number of claims in that year (37.5%), while the Professional, Scientific, and Technical Services sector filed the second-largest number (34.3%) (See Figure 11). Together, these two sectors accounted for almost 72 percent of all filed claims in 2013.

Figure 11: Federal R&D Research Credit Claimed by Business Sector, 2013

Sector	Number of returns claiming a credit	Percentage of All Claimed Credits
Agriculture, forestry, fishing, and hunting	92	0.6%
Mining	70	0.4%
Utilities	70	0.4%
Construction	341	2.1%
Manufacturing	**6,241**	**37.5%**
Wholesale and retail trade	1,100	6.6%
Transportation and warehousing	77	0.5%
Information	1,623	9.8%
Finance and insurance	274	1.6%
Real estate, rental, and leasing	68	0.4%
Professional, scientific, and technical services	**5,694**	**34.3%**
Management of companies (holding companies)	346	2.1%
Administrative support & waste mngt services	319	1.9%
All other services	309	1.9%
Total, All sectors	**16,624**	**100.0%**

Source: Internal Revenue Service, SOI Tax Statistics, 2019

While the IRS collects statistics on all research and development deductions claimed on Form 6765, it does not break this information down by business employment size or by receiving state. Therefore, it is not possible to use IRS data to measure small business R&D activity in Maryland. However, it is conceivable that the changes to the federal R&D Tax Credit by the PATH Act of 2015 will increase small business use of these credits, and perhaps drive more small business research in the State.

Small Business and the Maryland R&D Tax Credit. Maryland first adopted the Research and Development Tax Credit in 2000. Created by Chapters 515 and 516 of 2000, the R&D tax credit provides two types of credits: (1) a basic credit equal to 3% of the Maryland qualified R&D expenses paid during the tax year, up to the Maryland base amount; and (2) a growth credit equal to 10% of the Maryland qualified R&D expenses paid during the year that exceed the Maryland base amount. Since tax year 2016, the program has been funded at $12 million, with a maximum of $6.5 million in growth credits and $5.5 million in basic credits.

Except for certain businesses, the tax credit is nonrefundable – the value of the credit may not exceed the tax liability imposed in the tax year. Any unused amount of the credit may be carried forward for seven years after the taxable year in which the expense was incurred. The tax credit is refundable for small businesses, defined as a for-profit corporation, limited liability company, partnership, or sole proprietorship that, at the beginning or end of the taxable year in which the eligible R&D expenses are incurred, has net book value assets totaling less than $5 million.

While the value of the tax credit is pro-rated based on the total amount of funds available in the budget, businesses who apply are required to report the entire value of their research and development activities in the State in the tax year of the application. This total value is then used in the calculation of basic and growth credits. From Tax Year 2011 through Tax Year 2017, businesses have reported over $10 billion in R&D activity performed in the State. The value of reported activities has been steadily increasing, although this fact alone cannot necessarily be taken as evidence that R&D activities have also been increasing.

Figure 12: Reported Research Expenditures in Maryland, Tax Years 2011-17

Supersector	TY11	TY13	TY15	TY17	Total 2011-17
Construction	$12,574,461	$13,875,069	$15,141,738	$30,852,107	$139,529,359
Manufacturing	$767,697,644	$751,160,280	$1,187,084,239	$1,430,668,442	$7,001,440,730
Trade, Transportation, and Utilities	$21,299,558	$38,555,450	$30,424,638	$11,096,186	$176,957,902
Information	$162,341,888	$139,138,405	$141,681,942	$161,983,066	$1,108,742,413
Financial Activities	$1,211,453		$2,722,636	$32,041,645	$60,329,955
Professional and Business Services	$133,484,949	$166,657,836	$252,782,824	$406,651,587	$1,658,210,445
Education and Health Services	$6,581,225	$4,508,375	$4,204,678	$7,768,051	$49,438,811
Leisure and Hospitality					$45,874,446
Other Services		$51,090	$230,316		$382,496
Sector Unknown	$386,141	$39,007,592	$1,459,596	$48,421,936	$110,338,456
Grand Total	$1,105,577,319	$1,152,954,097	$1,635,732,607	$2,129,483,020	$10,351,245,013

Source: Maryland Department of Commerce

For Tax Year 2017, 354 companies claimed the R&D tax credit for research activities in Maryland. This was a significant increase in the number of firms claiming the credit over the previous year, and almost double the number of claiming firms from Tax Year 2011.

Figure 13: Number of Companies Filing for the Maryland R&D Tax Credit, Tax Years 2011-2017

Supersector	TY11	TY12	TY13	TY14	TY15	TY16	TY17	Total
Construction	8	8	7	16	11	17	19	86
Manufacturing	78	85	83	91	86	87	107	617
Trade, Transportation, and Utilities	12	16	15	10	13	12	13	91
Information	16	18	17	19	17	22	24	133
Financial Activities	1	1		2	2	2	3	11
Professional and Business Services	60	72	73	88	97	113	161	664
Education and Health Services	4	2	2	2	1	4	5	20
Leisure and Hospitality						1		1
Other Services			1	1	1			3
Sector Unknown	1	2	2	2	1	10	22	40
Grand Total	180	204	200	231	229	268	354	1,666

Source: Maryland Department of Commerce

As Figure 12 and Figure 13 show, the manufacturing and professional services supersectors were the source of most reported R&D in Maryland, with the manufacturing supersector reporting 68 percent of all expenditures and 37 percent of all filings, while Professional Services made up the largest percentage of companies claiming the credit, at 40 percent of all claimants from Tax Year 2001 through Tax Year 2017. These percentages are similar to what is seen by the federal R&D tax credit program, which implies that private firms carrying out research activities in Maryland have a similar profile to those on the National level.

Reviewing data for small businesses under this program shows a similar pattern, where the Manufacturing supersector reported expending the bulk of R&D funds in the State (66%) but filed the second-largest percentage of claims (31%), while the Professional Services sector was responsible for the majority of small business claimants (46%). See Figure 14 and Figure 15.

Figure 14: Small Business Research Expenditures in Maryland, Tax Years 2011-17

Supersector	TY11	TY13	TY15	TY17	Total 2011-17
Construction			$788,865	$1,847,737	$3,888,969
Manufacturing	$79,561,190	$36,894,314	$86,164,167	$200,624,128	$719,453,132
Trade, Transportation, and Utilities	$3,098,912	$9,750,045	$4,743,582	$1,945,869	$35,433,443
Information	$5,525,586	$4,425,581	$10,029,493	$6,044,122	$43,975,419
Financial Activities				$3,138,324	$3,138,324
Professional and Business Services	$28,696,312	$26,043,648	$35,100,170	$43,847,774	$244,288,877
Education and Health Services	$3,248,111	$2,639,277	$4,204,678	$5,961,757	$29,692,761
Leisure and Hospitality					
Other Services		$51,090	$230,316		$382,496
Sector Unknown	$386,141			$4,943,284	$16,261,498
Grand Total	$120,516,252	$79,803,955	$141,261,271	$268,352,995	$1,096,514,919

Source: Maryland Department of Commerce

Figure 15: Small Businesses Filing for the Maryland R&D Tax Credit, Tax Years 2011-2017

Supersector	TY11	TY12	TY13	TY14	TY15	TY16	TY17	Total
Construction				2	2	1	4	9
Manufacturing	20	27	29	28	21	23	32	180
Trade, Transportation, and Utilities	5	8	7	3	4	4	5	36
Information	6	5	7	9	6	9	11	53
Financial Activities							2	2
Professional and Business Services	30	30	33	37	38	42	57	267
Education and Health Services	3	1	1	1	1	2	3	12
Leisure and Hospitality								
Other Services			1	1	1			3
Sector Unknown	1	2				4	10	17
Grand Total	65	73	78	81	73	85	124	579

Source: Maryland Department of Commerce

Note that small businesses in Maryland who claimed the R&D tax credit made up 35 percent of all claimants, but reported only 11 percent of all R&D reported to the program between Tax Year 2011 and Tax Year 2017.

Reviewing the data to see only Maryland-based small businesses shows that, on average, these businesses report spending 4.6 percent of all research spending reported under the program, or a total of $479 million between TY 2011 and TY2017. On average, these businesses report spending $1.1 million on research. Actual reported spending ranges between $1,800 and $191 million, with a median of $396 thousand (See Figure 16).

Figure 16: Total Reported Value of Research by Maryland-Based Claimants Reporting Less Than $5 Million in Gross Receipts, 2011 to 2017

Tax Year	Number of Claimants	Total Reported R&D	Average Per Claimant	Median R&D Spending	Percent of Total R&D
TY11	50	$103,949,968	$2,078,999	$520,015	9.4%
TY12	53	$73,136,277	$1,379,930	$361,398	6.0%
TY13	61	$54,088,272	$886,693	$389,947	4.7%
TY14	60	$47,664,421	$794,407	$271,378	3.2%
TY15	53	$54,566,796	$1,029,562	$349,408	3.3%
TY16	63	$63,114,102	$1,001,811	$426,694	3.8%
TY17	96	$82,784,348	$862,337	$465,647	3.9%
Grand Total	436	$479,304,184	$1,099,322	$396,073	4.6%

Source: Maryland Department of Commerce

Maryland Small Businesses Receiving Federal Funds. As was mentioned earlier, Maryland ranks highly in the total amount of federal funds expended within the State. In FY2019, 33.8 percent of all Federal obligations whose place of performance was in Maryland were obligated to small businesses (see Figure 17).

Figure 17: Maryland Place-of-Performance Federal Spending Obligations by Major Agency and Small Business Determination, FY2019

Awarding Agency	Other Than Small Business	Small Business	Total	Percent Small Business	Percent Total Spending
Defense	$9,875,164,757	$3,843,459,239	$13,718,623,996	28.0%	41.5%
Health & Human Services	$3,010,219,048	$1,866,066,319	$4,876,285,366	38.3%	14.7%
Energy	$2,687,951,236	$236,454,740	$2,924,405,976	8.1%	8.8%
NASA	$1,111,822,661	$621,161,974	$1,732,984,634	35.8%	5.2%
Homeland Security	$739,916,563	$691,884,813	$1,431,801,377	48.3%	4.3%
GSA	$879,674,621	$302,889,369	$1,182,563,991	25.6%	3.6%
Commerce	$167,342,737	$824,527,863	$991,870,601	83.1%	3.0%
USAID	$598,275,714	$187,857,989	$786,133,703	23.9%	2.4%
Transportation	$350,535,298	$263,238,637	$613,773,935	42.9%	1.9%
Justice	$374,132,641	$237,990,803	$612,123,444	38.9%	1.9%
Veterans Affairs	$239,563,936	$280,068,600	$519,632,536	53.9%	1.6%
Dept of State	$114,863,931	$398,379,837	$513,243,767	77.6%	1.6%
Treasury	$151,596,159	$360,223,439	$511,819,598	70.4%	1.5%
Smithsonian	$364,097,300	$39,326,316	$403,423,617	9.7%	1.2%
USDA	$82,769,547	$244,039,464	$326,809,011	74.7%	1.0%
NSF	$307,838,570	$9,526,813	$317,365,383	3.0%	1.0%
Social Security	$269,925,499	$39,340,328	$309,265,827	12.7%	0.9%
Dept of the Interior	$141,587,989	$105,172,328	$246,760,317	42.6%	0.7%
Education	$110,698,428	$108,071,649	$218,770,077	49.4%	0.7%
Labor	$84,488,578	$104,249,559	$188,738,137	55.2%	0.6%
TOTAL SPENDING	$21,891,534,728	$11,188,504,637	$33,080,039,366	33.8%	

Source: USASpending.gov

Basic statistics on federally-funded R&D performed by small businesses (including SBIR / STTR contract awards) show that, in total, 18.8 percent of all contract awards for research-oriented product or service codes (POSCs) in Maryland in 2019 were awarded to small businesses. While there is some variation in the small business percentage between agencies, the four agencies that account for 95 percent of all research contracts in the State (Defense, HHS, NASA, and NSF) all cluster around this percentage. NASA has the highest percentage of awards to small business (32%), while NSF awarded no contracts to small businesses for research in FY2019. Even though the Department of Defense awarded only 15 percent of its research contracts to small businesses whose place of performance is Maryland, this amount still accounts for almost 40 percent of all small business research contracts performed in Maryland (See Figure 18).

Figure 18: Maryland Place-of-Performance Federal Spending Obligations for Research Activities by Major Agency and Small Business Determination, FY2019

Awarding Agency	Other Than Small Business	Small Business	Total	Percent Small Business	Percent Total Spending
Defense	$2,027,887,913	$359,447,795	$2,387,335,708	15.1%	49.1%
Health & Human Services	$927,456,800	$159,277,683	$1,086,734,482	14.7%	22.3%
NASA	$569,593,968	$268,160,031	$837,754,000	32.0%	17.2%
NSF	$291,623,772	-	$291,623,772	0.0%	6.0%
Homeland Security	$38,157,723	$59,677,193	$97,834,916	61.0%	2.0%
Transportation	$60,969,368	$11,398,945	$72,368,313	15.8%	1.5%
Energy	$2,557,337	$37,677,509	$40,234,846	93.6%	0.8%
USAID	$14,532,448	-$10,284	$14,522,163	-0.1%	0.3%
Education	$3,660,701	$4,838,789	$8,499,490	56.9%	0.2%
Interior	$766,150	$5,593,732	$6,359,882	88.0%	0.1%
Commerce	$793,193	$5,189,670	$5,982,862	86.7%	0.1%
Veterans Affairs	$5,484,411	$185,540	$5,669,951	3.3%	0.1%
State	$1,930,021	$1,880,985	$3,811,005	49.4%	0.1%
USDA	$2,375,033	-$244,463	$2,130,570	-11.5%	0.0%
HUD	$1,548,319	$235,502	$1,783,821	13.2%	0.0%
GSA	-	$1,633,808	$1,633,808	100.0%	0.0%
NRC	$628,543	$105,000	$733,543	14.3%	0.0%
Export-Import Bank	-	$709,537	$709,537	100.0%	0.0%
CNCS	$436,133	-	$436,133	0.0%	0.0%
EPA	$350,821	$7,792	$358,613	2.2%	0.0%
Smithsonian Institution	$70,000	$181,346	$251,346	72.1%	0.0%
Treasury	$159,470	-	$159,470	0.0%	0.0%
Broadcasting Board of Governors	$11,000	$8,000	$19,000	42.1%	0.0%
Total, All Research Spending	$3,950,993,124	$915,954,109	$4,866,947,232	18.8%	100.0%

Source: USASpending.gov

Known Issues with Tracking Federal Small Business Spending. Because investing in small business is important to the State's economy, Maryland has attempted to track work by federal contractors that is subcontracted to other companies or organizations. All federal contracts are overseen by a **prime contractor**, or the organization that directly received a contract for goods or services from the federal

government. The prime contractors are often allowed to subcontract portions of this work to other organizations or companies. These direct subcontractors are known as **first-tier subcontractors**, and data on them is generally available. However, data on the subcontractors to these first-tier subcontractors, known as **lower-tier subcontractors**, can be difficult or impossible to obtain. Many of these lower-tier subcontractors may be small businesses located in Maryland, even in cases where the prime contractor is an organization located in another state. Therefore, Maryland firms may be indirectly receiving federal funding to perform work on federal contracts and not be recognized for their efforts because they do not show up in official data sources.

The Federal Small Business Administration has been working to improve data collection on lower-tier subcontractors, and issued a final rule in 2016 "to amend the federal small business subcontracting plan requirements in order to allow other than small (i.e., large in SBA-speak) federal prime contractors to receive credit for lower-tier subcontracting awards to small business concerns (SBCs) and other socio-economically disadvantaged SBCs."[16] This new rule was effective on January 23, 2017. This rule has been followed by a proposal by the Department of Defense, GSA, and NASA to "amend the Federal Acquisition Regulation (FAR) to align with prior changes by the Small Business Administration (SBA) concerning credit for lower-tier small business subcontracting."[17] This rule change would affect FAR 19.704 and 52.219-9 to ensure that "other than small business" prime contractors (i.e. any prime contractor who is not a small business) would report small businesses who are lower-tier subcontractors toward their required small and disadvantaged business contracting goals.

As this rule change has not yet been implemented at the time of the creation of this report, there is no data to report on how small business contracting numbers would be affected. However, it is hoped that data on small business subcontracting will become more available over time, and that this will allow the State of Maryland to better track small business involvement in the federal contracting process.

Targeting Small Business Firms Engaged in Research. The information above shows that there are firm types who are likely to perform research, and firm types who are not. Comparing data from the federal and State R&D tax credit programs shows that firms in the Manufacturing, Professional Services, Information, and Wholesale & Retail trade sectors together account for approximately 90 percent of filings in both programs, and State-level data shows that this percentage breakdown also applies to Maryland's small businesses. Therefore, any program attempting to improve Maryland small businesses' participation in federal research should start by targeting these sectors. As a review of small business data shows, there are tens of thousands of small businesses in these supersectors in Maryland (See Figure 19).

[16] https://governmentcontracts.foxrothschild.com/2016/12/articles/federal-government/awards-to-lower-tier-small-business-subcontractors-finally-count-towards-small-business-subcontracting-goals/
[17] https://governmentcontracts.foxrothschild.com/2019/06/articles/general-federal-government-contracts-news-updates/contractor-update-credit-for-lower-tier-subcontracts-toward-small-business-subcontracting-goals/

Figure 19: Maryland Small Businesses in Research-Heavy Sectors, 2019

Supersector	Micro (0 to 9 Employees)	Small (10 to 49 Employees)	All Firms Under 50 Employees	Percentage of All Firms in Maryland
Manufacturing	2,341	854	3,195	89.6%
Trade, Transportation, and Utilities	20,055	3,749	23,804	95.3%
Information	1,987	286	2,273	94.9%
Professional and Business Services	31,908	5,061	36,969	96.3%

Source: Maryland Department of Labor, Commerce calculations, 2019

Most of these businesses fall under the Maryland Department of Commerce's Key Industry sectors. At the time of the creation of this report, these key sectors are:

- Aerospace & Defense
- Advanced Manufacturing
- Agribusiness
- BioHealth & Life Sciences
- IT & Cybersecurity
- Distribution & Logistics
- Energy & Sustainability
- Military & Federal

Maryland Support. Maryland's State government has a long history of supporting small business in the State, and of assisting small business with the federal procurement process. Because of the high integration between federal government activities and Maryland's economy, the State of Maryland has instituted programs to support Maryland businesses in their efforts to work with federal agencies.

Programs that can be utilized by Maryland's small businesses to assist them in engaging in federal research and development are the: Employer Security Clearance Tax Credit; Maryland Defense Cybersecurity Assistance Program (DCAP); Maryland Procurement Technical Assistance Center (MD PTAC); Maryland Defense Technology Commercialization Center (DefTech); Maryland Federal Facilities Contracting Guide; Defense Patent Database; and Maryland Defense Network. Discussion of these programs is provided on pages thirteen through sixteen of this report.

Other programs administered by the Department of Commerce that can assist businesses that receive federal contracts or grants but are not specifically oriented to obtaining federal support are the: Sales and Use Tax Exemption for Purchases for Research and Development; Biotechnology Investment Incentive Tax Credit; Cybersecurity Investment Incentive Tax Credit; Research and Development Tax Credit; Maryland Technology Internship Program (MTIP); TEDCO Seed Investment Fund; and UM Maryland Industrial Partnership (MIPS) Program. Discussion of these programs is provided in the Existing Programs section of this report.

(1)(iii) Explore ways to facilitate the transfer of technology from small businesses[18]

The universe of federal technology transfer is complex, and has been the subject of numerous studies, reports, and books. While there are many resources available to companies who may want to take advantage of technology transfer options offered by federal agencies, the sheer volume of federal research and the multiple ways in which a company could conceivably obtain transferred technology make it difficult for the uninitiated to become involved in the federal technology transfer system. In addition, there are other entities other than the federal government who may be sources of technology transfer, especially universities.

The following is a concise review of technology transfer methods that are available to small businesses, and a review of the known issues that create difficulties for companies in participating in the tech transfer system.

Important R&D-Related Federal Legislation and Regulations.

There are many federal laws and regulations that support technology transfer. Some of the more important are described below. A full accounting of the laws and regulations controlling federal technology transfer can be found in the 175 pages of the sixth edition of *The Green Book* published by the Federal Laboratory Consortium for Technology Transfer.

*Executive Order 10096 of 1950***.** Federal law states that works created by the federal government cannot be domestically protected by copyright, and are therefore in the public domain.[19] However, the same is not true for patentable work, as it is possible for research performed by the federal government to be patented and for the patent to be assigned to the federal government. Moreover, the federal government has the right to take full or partial ownership of any patents that are derived from government-funded work performed by government employees.

The Bayh-Dole Act of 1980. While inventions created by federal employees working at federal facilities are clearly patentable only by the federal government, the rights of federal contractors and academic researchers were not always clear. Under the Bayh-Dole Act of 1980 (94 Stat. 3015 and 35 U.S.C. § 200–212, regulated by 37 C.F.R. 401 and 37 C.F.R 404), the federal government standardized the method in which rights over inventions that are created by federal contractors or funded by federal funds are assigned. Under the act, federally-contracted or funded inventors generally have the right to retain control over their invention, but are required to timely disclose the details of their invention to the Government and to elect to retain ownership of the invention. Failure to do either can mean that the federal government will elect to take control of the patent. This act also allows the federal government to assign exclusive licenses to firms to commercialize patented federal research.[20]

The Technology Innovation Act and Amendments. The Stevenson-Wydler Technology Innovation Act of 1980 allows laboratories owned and operated by the government to enter into cooperative research

[18] Note: While Chapter 306 of 2019 uses this wording, this section assumes that the statute was intended to read "*to* small businesses," not "*from* small businesses."
[19] https://www.law.cornell.edu/uscode/text/17/105
[20] https://en.wikipedia.org/wiki/Bayh%E2%80%93Dole_Act

and development agreements (CRADAs). Prior to this Act, technology transfer was not a part of the mission of most federal agencies. This Act was amended by the Federal Technology Transfer Act (FTTA) of 1986 - 15 USC 3710 in 1986, which built on the Stevenson-Wydler Act of 1980. FTTA improves access to federal laboratories by non-federal organizations and requires "[a]ll federal laboratory scientists and engineers . . . to consider technology transfer an individual responsibility."[21] It also allows government inventors to patent their technologies and receive a share of the royalties when patents are licensed.[22] Other, more recent Acts have expanded and clarified the ability of federal labs to enter into research partnerships with private industry.

The Small Business Innovation Development Act of 1982. The Small Business Innovation Development Act of 1982 (P.L. 97-219) established the Small Business Innovation Research (SBIR) Program, requiring agencies to provide special funds for small business R&D connected to the agencies' missions. This program is discussed in detail in the next section of this report.

Executive Order 12591 (1987). Executive Order 12591, Facilitating Access to Science and Technology (1987), requires "agency and laboratory heads to identify and encourage individuals who would act as conduits of information among federal laboratories, universities, and the private sector." The order requires, "to the extent permitted by law, laboratories grant to contractors the title to patents developed in whole or in part with federal funds, as long as the government is given a royalty-free license for use."[23]

The Omnibus Trade and Competitiveness Act of 1988. The Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418) created the Hollis Manufacturing Extension Partnership program.

The Small Business Research and Development Enhancement Act of 1992. The Small Business Research and Development Enhancement Act (P.L. 102-564) established the Small Business Technology Transfer (STTR) Program, which is discussed in detail in the following section of this report.

Federal Technology Transfer Channels. There are five major channels through which federal technology transfer activities occur:

1. *Commercial transfer*: The movement of knowledge or technology developed by a federal laboratory to private organizations or the commercial marketplace;
2. *Scientific dissemination*: Publications, conference papers, and working papers distributed through scientific or technical channels, or other forms of data dissemination;
3. *Export of resources*: Federal laboratory personnel made available to outside organizations with R&D needs, through collaborative agreements or other service mechanisms;
4. *Import of resources*: Outside technology or expertise brought in by a federal laboratory to enhance existing internal capabilities; and

[21] FLC. 2019. Federal Technology Transfer Legislation and Policy: The Green Book, 6th Edition. Prepared by the Federal Laboratory Consortium for Technology Transfer. P. xii.
[22] https://www.epa.gov/ftta/federal-technology-transfer-act-and-related-legislation
[23] FLC. 2019. Federal Technology Transfer Legislation and Policy: The Green Book, 6th Edition. Prepared by the Federal Laboratory Consortium for Technology Transfer. P. xiii.

5. *Dual use*: Development of technologies, products, or families of products with commercial and Federal [mainly military] applications.[24]

Commercial Transfer. The federal government regularly creates both patented and unpatented research within its own facilities, known generally as "intellectual property" or IP. This IP is made available to private corporations for licensing. Some IP is made available for exclusive licensing, while some is made available under non-exclusive licenses. Before any IP can be made available for exclusive licensing, a "Notice of Intent To Grant an Exclusive Patent License" must first be published in the Federal Register to give any competing company 15 days to object.[25]

Import and Export of Resources (Talent Exchange). The various mechanisms available to private companies, academic institutions, and nonprofits for exchanging personnel to advance technology transfer include:

- *"Cooperative Research & Development Agreements (CRADAs)*: A CRADA is a written agreement between a federal laboratory and a non-federal party that legally binds them together in joint research that is consistent with the laboratory's mission. CRADAs are the dominant channel for technology transfer between federal laboratories and the private sector – and can also serve as the basis for personnel exchanges.
- *Entrepreneurial Leave Programs*: A federal laboratory may set up a mechanism that permits staff to take "entrepreneurial leave," spending time focused on commercializing a technology developed in the laboratory. With current examples at the Department of Energy (DOE) and the Department of Defense (DOD), this type of personnel exchange is also called an "Entrepreneurial Separation to Transfer Technology."
- *Entrepreneur-in-Residence (EIR) Programs*: Entrepreneurs from outside of government who wish to apply their skills for the benefit of the public good can do so through EIR programs. EIRs are typically mid- to senior-level professionals and may be academics, technology entrepreneurs, software designers, policymakers, business experts, or non-profit leaders who have demonstrated a significant record of innovative achievement in their field. NIST, the National Institutes of Health (NIH), the Department of Homeland Security, and other federal agencies operate EIR programs.
- *Public-Private Entrepreneurial Partnerships*: A number of entrepreneurial partnerships have been instituted between federal laboratories and the private sector for placement of personnel. For instance, the DOE's Lawrence Berkley National Laboratory provides a home for entrepreneurial clean-energy researchers through Cyclotron Road, a $5 million public-private partnership to advance energy technologies until they can succeed beyond the lab. Similarly, the Oak Ridge Institute for Science and Education (ORISE) is an agreement between the U.S. Department of Agriculture and DOE, where candidates such as students, post-graduates, or established scientists can be hired into a variety of research-related positions.
- *Strategic Partnership Programs*: A contractor-operated federal laboratory may advise a U.S. company or researcher on problems for which the laboratory has special expertise or

[24] https://www.nsf.gov/statistics/2018/nsb20181/report/sections/invention-knowledge-transfer-and-innovation/knowledge-transfer
[25] https://www.federalregister.gov/documents/2019/04/12/2019-07287/notice-of-intent-to-grant-an-exclusive-patent-license

equipment. Work is done under a formal agreement on a full-cost-recovery basis if the assistance requires more than an incidental amount of time.

- *Use of Facilities Agreements*: Outside entities such as universities, technology incubators, private companies, and individual inventors may be able to use specialized equipment, specialized rooms, testing centers or other unique experimental property of the federal laboratories. Costs are typically paid by the user.
- *Visiting Scientist Programs*: Personnel from private industry can arrange to work for limited periods of time in a federal laboratory. These arrangements are usually limited to 6-12 months and, depending on the arrangement, costs can be borne by the laboratory or by the organization sending the personnel. Intellectual property arrangements can also be addressed in the exchange agreement. Ames Laboratory (DOE) and the Frederick National Laboratory for Cancer Research (NIH) currently administer such visiting scientist programs.
- *Educational Partnership Agreements (EPAs)*: An EPA is an agreement between DOD and educational institutions to encourage and enhance the study of scientific disciplines. Under an EPA, DOD laboratory directors may make laboratory personnel available to teach science courses or to assist in the development of science courses and materials. Directors may also provide for sabbatical opportunities for faculty and internship opportunities for students at the institution, and cooperate with the institution in developing a program under which students may earn academic credit for working on DOD laboratory projects."[26]

Dual-Use Technology Transfer. Dual-Use technology transfer refers to technology development processes and programs that are "planned and specifically developed for dual-use application by the government and the commercial market."[27] These development programs are intended to "allow the armed forces to exploit the rapid rate of innovation and market-driven efficiencies of commercial industry to meet defense needs" while ensuring that "the innovation and accomplishments that originate in defense programs and laboratories will move rapidly to the commercial sector."[28]

Statistics on Federal Technology Transfer. As Figure 20 shows, the majority of federal tech transfer happens through collaborative R&D relationships, be they Cooperative Research & Development Agreements (CRADAs), the largest single method of collaboration, or through the many other types of talent exchanges mentioned previously. The second most significant source of tech transfer is through licenses, either of patented or non-patented inventions or other intellectual property licenses. Note that patented federal research makes up a minority of federal transfer activity.

[26] https://obamawhitehouse.archives.gov/blog/2016/11/22/lab-market-commercializing-new-technologies-exchanging-talent
[27] https://www.onr.navy.mil/en/work-with-us/technology-transfer-t2
[28] https://clintonwhitehouse1.archives.gov/White_House/EOP/OSTP/nssts/html/chapt2-2.html

Figure 20: Federal Technology Transfer Activity, 2014

Technology transfer activity	All federal laboratories	DOD	HHS	DOE	NASA	USDA	DOC	DHS
Invention disclosures and patenting								
Inventions disclosed	5,103	963	351	1,588	1,683	117	47	36
Patent applications	2,609	916	216	1,144	146	119	25	5
Patents issued	1,931	670	335	693	117	83	18	3
Licensing								
All licenses, total active in the fiscal year	20,822	527	1,555	5,861	2,381	414	41	10,313
Invention licenses	3,956	425	1,186	1,560	253	363	41	2
Other intellectual property licenses	16,866	102	369	4,301	2,128	51	0	10,311
Collaborative relationships for R&D								
CRADAs, total active in the fiscal year	9,180	2,762	532	704	0	267	2,359	158
Traditional CRADAs	4,891	2,281	378	704	0	193	206	121
Other collaborative R&D relationships	27,182	581	154	0	6,058	17,005	3,031	31

Source: National Science Foundation, Science and Engineering Indicators 2018 (NSB-2018-1), Table 8.3

Location of Federal Inventors on Federal Patents. Between 2008 and 2017, the federal government was the assignee or co-assignee on 9,786 utility patents, of which 1,196 had non-federal co-assignees. Less than one percent of the 1.2 million utility patents issued in that time period were issued to the federal government. The vast majority of the federal assignees who own patents list their location as Washington, D.C., a statistic that does not reveal much about where the research supporting that patent has been performed.

Figure 21: Total of Inventors Listed in Federally-Assigned Patents, 2008 to 2017

State	All Listed Inventors	Percentage of Listed Inventors
United States Total	28,788	-
Maryland	7,343	25.5%
Virginia	3,827	13.3%
California	3,715	12.9%
New Jersey	1,151	4.0%
Ohio	1,058	3.7%

Note: The same inventor may be listed on multiple patents

Source: U.S. Patent and Trademark Office, 2019

However, the location of the listed inventors on each patent can also be examined, and that gives a picture of where patented federal research is being performed. As Figure 21 shows, over one-quarter of all listed inventors on federally-assigned patents between 2008 and 2017 were located in Maryland. An additional 13 percent were located in neighboring Virginia. The only other state with a significant presence of inventors on federal patents was California, also at 13 percent. While patents are not the main source of federal technology available for transfer, these findings imply that federal labs in Maryland are a major source of tech transfer resources.

University Technology Transfer. The federal government is not the only place where small businesses can find technology to transfer. Maryland's universities have business offices that coordinate with private industry to develop, evaluate or transfer technology. Maryland businesses benefit from development and evaluation services that are easy to access and which save program development time and expenses. These unique assets are distributed around the state in suburban, urban, and rural locations. Companies in Maryland are well served not only by the access to the technology transfer occurring daily in these R&D centers but also by the potential to reach these agencies as customers for goods and services.

Non-federal educational links to business include:

- The USM Institute for Bioscience and Biotechnology Research
- The Maryland Technology Enterprise Institute at College Park
- The Fraunhofer Center for Experimental Software Engineering at the University of Maryland
- The UMBC Center for Cybersecurity
- The Johns Hopkins University Information Security Institute
- The University of Maryland School of Medicine Center for Vaccine Development.

Maryland Technology Transfer Resources. The State of Maryland has long recognized the importance of technology transfer to Maryland businesses. To further these goals, the State has developed its own programs to assist in technology transfer activities. These programs include the: Maryland Defense Technology Commercialization Center (DefTech); Defense Patent Database; Maryland Procurement Technical Assistance Center (MD PTAC); TECO Seed Investment Fund; UM Maryland Industrial Partnership (MIPS) Program; University of Maryland and University of Baltimore's MPower Program; and the Maryland Manufacturing Extension Partnership. In addition to State resources, there are also private academic resources available for tech transfer in Maryland. Discussion of these programs is provided in the Existing Programs section of this report.

Improving the Technology Transfer Process. The federal government has been involved in an iterative process to improve its technology transfer processes since the passage of the Bayh-Dole Act in 1980. In 2017, Maryland Commerce and NIST partnered to host the Technology Transfer Summit. The summit brought together stakeholders in technology transfer to discuss barriers to, and opportunities to improve, federal technology transfer.

NIST Return on Investment Initiative. In 2018, as a follow up to the Technology Transfer Summit, NIST organized stakeholder feedback on technology transfer from federal labs. The input was written into a green paper titled "Return on Investment Initiative," and the final draft was published in April 2019. A summary of their findings is below:

Strategy 1: Identify regulatory impediments and administrative improvements in federal technology transfer policies and practices

- Government Use License: According to stakeholders, the scope of the "government use license" is not well defined
- March-In Rights: According to stakeholders, the circumstances under which the government may appropriately exercise march-in rights to license further development of an invention to achieve practical application are not clear

- Preference for U.S. Manufacturing: According to stakeholders, existing statute supports the preference for U.S. manufacturing but the process to obtain a waiver is confusing
- Copyright of Software: According to stakeholders, the "Government Works" exception to copyright protection for software products of federal R&D at Government-Owned, Government-Operated Laboratories constrains commercialization
- Proprietary Information: According to stakeholders, an expanded protection period for proprietary information under a Cooperative R&D Agreement would encourage greater collaboration with federal laboratories
- Strengthen Technology Transfer at Federal Laboratories: According to stakeholders, updates to policies and practices under the Stevenson-Wydler Act could be simplified
- Presumption of Government Rights to Employee Inventions: According to stakeholders, the process to determine a present assignment of invention rights by federal employees to the federal government is overly burdensome

Strategy 2: Increase engagement with private sector technology development experts and investors

- Streamlined Partnership Mechanisms: According to stakeholders, improved clarity and use of best practices government-wide would streamline agreements and ensure greater transparency for R&D partners
- Expanded Partnership Mechanisms: According to stakeholders, private sector investment for translational R&D and technology maturation could be increased through expanded partnership agreements and nonprofit foundations
- Technology Commercialization Incentives: According to stakeholders, recipients of federal funding could benefit from a limited use of R&D funding awards to enable intellectual property protection

Strategy 3: Build a more entrepreneurial R&D workforce

- Technology Entrepreneurship Programs: According to stakeholders, expanding technology entrepreneurship programs at federal R&D agencies government-wide will help build a more entrepreneurial workforce
- Managing Conflicts of Interest: According to stakeholders, current requirements for managing conflicts of interest pose challenges to build a more entrepreneurial R&D workforce

Strategy 4: Support innovative tools and services for technology transfer

- Federal IP Data Reporting System(s): According to stakeholders, a secure, modern platform is not available for reporting data on intellectual property resulting from federal R&D
- Access to Federal Technologies, Knowledge, and Capabilities: According to stakeholders, a federated data portal is not available to easily access, use, and analyze information on federally funded technologies, knowledge, and capabilities that are available to the public

Strategy 5: Improve understanding of global science and technology trends and benchmarks

- Benchmarking and Metrics: According to stakeholders, current metrics to capture, assess, and improve broad technology transfer outcomes and impacts based on federally funded R&D and underpinning operational processes are inadequate

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(1)(iv) explore ways to encourage small businesses to apply for federal SBIR/STTR grants

The Small Business Innovation Research / Small Business Technology Transfer (SBIR/STTR) programs are designed to help domestic small businesses gain federal support for their Research / Research and Development (R/R&D) efforts. The SBIR and STTR programs each have three phases: Phase I provides awards to test the feasibility and commercial potential of projects; Phase II offers further federal support to projects that showed technical merit and commercial potential; and Phase III is for small businesses to pursue commercialization objectives resulting from the Phase I/II R/R&D activities (http://www.sbir.gov/about/about-sbir). SBIR/STTR programs outside of the Department of Defense do not fund or track Phase III activities, but funding for these activities are reported in the USASpending database.

SBIR and STTR Program Purpose. The Small Business Administration refers to the SBIR and STTR programs as "America's Seed Fund."[29] According to SBA, the goals of these programs are to:

- Meet federal research and development needs;
- Increase private-sector commercialization of innovation derived from federal research and development funding;
- Stimulate technological innovation;
- Foster and encourage participation in innovation and entrepreneurship by women and socially/economically disadvantaged individuals; and
- Foster technology transfer through cooperative R&D between small businesses and research institutions (STTR).[30]

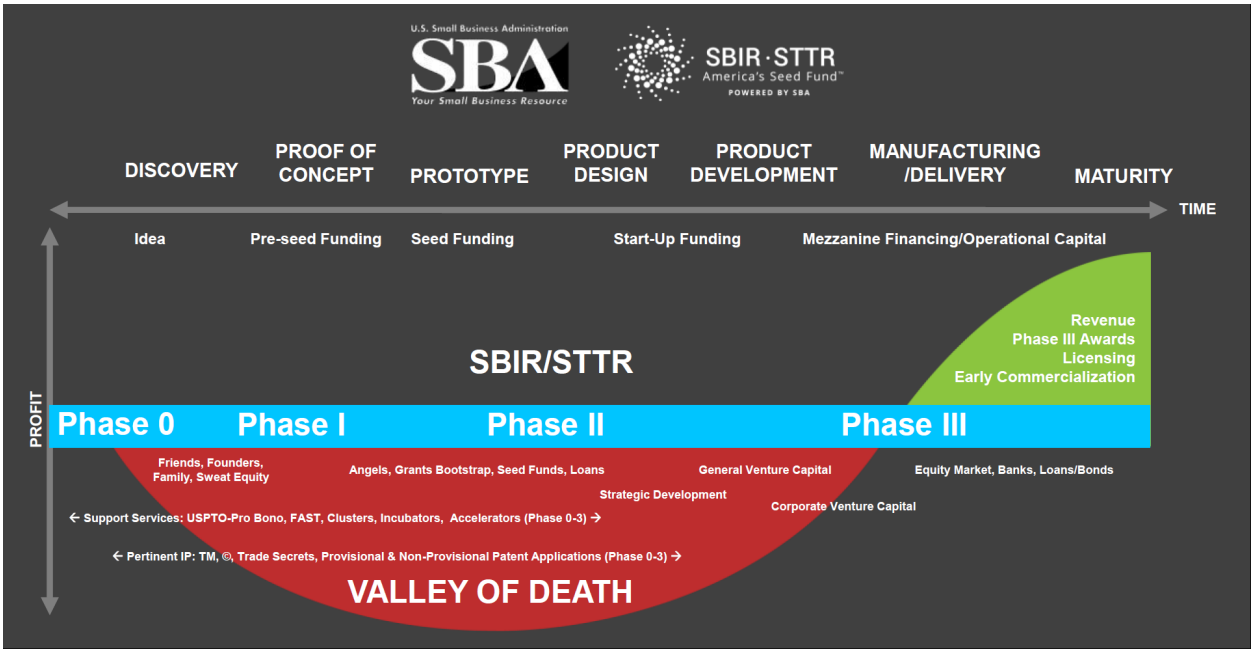
The SBA lists the following as reasons for using SBIR or STTR funding to fund small business research projects:

- Non-Diluted Capital. Under the SBIR and STTR programs, the federal funding agency does not take an equity position or ownership position in a firm. This differs from private funding sources, which may require an equity position in exchange for funding.
- IP/Data Rights protection. The federal government is prohibited from sharing reports or data resulting from research projects with entities outside of the federal government for either 5 years (DoD projects only) or 4 years (projects from all other agencies).
- Direct follow on Phase III awards. For agencies that give out Phase III funding, these awards can be given out without further competition, which benefits both the government and small businesses.[31]

One of the reasons why the SBIR and STTR programs are important to small businesses is to get them through the "valley of death," which represents the time when a business is expending funds to develop new products without deriving income from those products. Without funding to bridge the gap between R&D and product commercialization, a company can fail before it can bring a product to market.

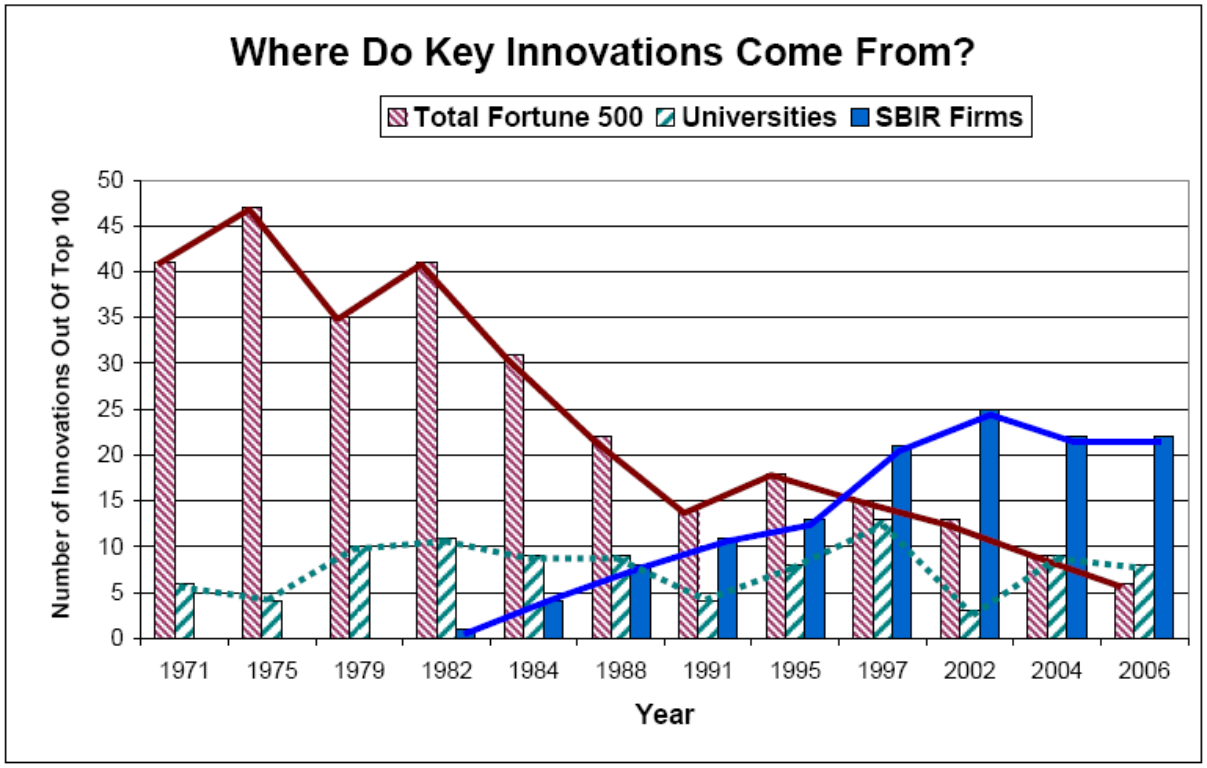
[29] https://www.sbir.gov/sites/default/files/2018%20SBIR%20Road%20Tour_New%20England_Slides.pdf
[30] Ibid.
[31] https://www.sbir.gov/sites/default/files/2018%20SBIR%20Road%20Tour_New%20England_Slides.pdf

Figure 22: SBIR/STTR Phases and the Valley of Death



Source: Small Business Administration

Figure 23: Source of Key Innovations, 1971-2006



Source: Testimony of Robert Schmidt, National Co-Chair, Small Business Technology Council: Before the Committee on Small Business, UNITED STATES HOUSE OF REPRESENTATIVES, Washington, D.C. , May 21, 2014.

A study from the National Academy of Sciences found that the SBIR and STTR programs were becoming more likely over time to be responsible for "key innovations, "with small companies being key players in bringing new technologies to market and SBIR/STTR funding being important component of small company research funding.[32]

SBIR and STTR Program Funding Agencies. The Small Business Innovation Research (SBIR) program was initially created at the National Science Foundation in 1977 as an NSF-only program, and legislation was adopted in 1982 to spread it government-wide[33] "with the purpose of strengthening the role of innovative small business concerns in federally-funded research and development (R&D)." Eleven federal agencies currently participate in the SBIR program:

- Department of Agriculture
- Department of Commerce
    - National Institute of Standards and Technology (NIST)
    - National Oceanic and Atmospheric Administration (NOAA)
- Department of Defense
- Department of Education
- Department of Energy
- Department of Health and Human Services
- Department of Homeland Security
- Department of Transportation
- Environmental Protection Agency (EPA)
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)

Each of these federal agencies currently has an extramural research and development (R&D) budget that exceeds the minimum $100 million threshold that requires SBIR participation, so each is required to allocate 3.2 percent (as of FY 2017) of this extramural R&D budget to SBIR and STTR funding. "Each agency administers its own individual program within guidelines established by Congress. These agencies designate R&D topics in their solicitations and accept proposals from small businesses. Awards are made on a competitive basis after proposal evaluation."[34]

The Small Business Technology Transfer (STTR) program was modeled after the Small Business Innovation Research (SBIR) program and was established in 1992. Government agencies with R&D budgets of $1 billion or more are required to set aside 0.45 percent of these funds (as of FY2017) to fund the program. "The goal of the STTR program is to facilitate the transfer of technology developed by a research institution through the entrepreneurship of a small business concern."[35] Like SBIR, agencies designate their own R&D topics and awards are made on a competitive basis. Currently there are five agencies who are required to participate in the STTR program:

- Department of Defense

[32] From Concept to Practice The NRC Assessment of the SBIR Program, The National Academies, Washington DC, March 19, 2015, Jacques Gansler, NAE, University of Maryland
[33] https://www.sbir.gov/tutorials/program-basics/tutorial-5
[34] https://www.sbir.gov/about/about-sbir
[35] https://www.sbir.gov/about/about-sttr

- Department of Energy
- Department of Health and Human Services
- National Aeronautics and Space Administration (NASA)
- National Science Foundation (NSF)

There are two major differences between the SBIR and STTR programs. "First, an STTR project requires the small business – which is always the applicant – to be teamed with a non-profit research institution, typically a university or federal laboratory. The second difference is that the STTR program is focused on the transfer of technology from the Research Institution, also referred to as the RI, to the small business and ultimately to the marketplace through a Phase 1-2-3 sequence. This second difference has been expanded over time to include situations where the innovation belongs to the small business, but the firm desires to include important resources from a nonprofit RI in the technology's development."[36]

Note that some agencies award SBIR and STTR *contracts*, while others award *grants*. The difference is that contracting agencies generally establishes the scope of work and research topic for the SBIR or STTR award and put in place binding agreements that control schedules and deliverables. Granting agencies generally allow the SBIR or STTR applicant to set their own scope of work and have no expectation that a research project will result in a specific outcome. There are five agencies that participate in the SBIR and / or STTR programs as contracting agencies (Defense, NASA, Homeland Security, Transportation, and the EPA), three that participate as granting agencies (Energy, NSF, USDA, and Commerce/NIST), and one that may use either grants or contracts (DHHS).[37]

In FY 2019, the SBIR program received $3.28 billion in funding, while the STTR program received $453 million in funding.[38]

SBIR / STTR Program Eligibility. Only small businesses owned and based in the United States are eligible to participate in the SBIR or STTR programs. An SBIR / STTR awardee must meet the following criteria at the time of Phase I and II awards:

- Organized for profit, with a place of business located in the United States;
- More than 50 percent owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States, or by another for-profit business concern that is more than 50% owned and controlled by one or more individuals who are citizens of, or permanent resident aliens in, the United States; and
- No more than 500 employees, including affiliates

For SBIR awards from agencies using the authority under 15 U.S.C. 638(dd)(1), an awardee may be owned and controlled by more than one VC, hedge fund, or private equity firm so long as no one such firm owns a majority of the stock.[39] Companies applying for STTR funding cannot be owned by venture capital firms.

Phase I awardees with multiple prior awards must meet the benchmark requirements for progress toward commercialization. These include a ratio of Phase II to Phase I awards of at least 0.25 (4 to 1)

[36] https://www.sbir.gov/tutorials/program-basics/tutorial-3
[37] https://www.sbir.gov/sites/default/files/SBIR-STTR_Outreach_One_Pager.pdf
[38] https://www.sbir.gov/sites/default/files/SBIR-STTR_Outreach_One_Pager.pdf
[39] https://www.sbir.gov/about

over the most recent 5-year period and / or an average of at least $100,000 of sales and/or investments per Phase II award received, or a number of patents equal to or greater than 15% of the number of Phase II awards received over the most recent 10-year period.[40]

SBIR / STTR Program Structure. Both the SBIR and STTR programs are structured as three phase programs:

- **Phase I**. The objective of Phase I is to establish the technical merit, feasibility, and commercial potential of the proposed R/R&D efforts and to determine the quality of performance of the small businesses prior to providing further federal support in Phase II. SBIR Phase I awards normally do not exceed $150,000 total costs for six months,[41] while STTR Phase I awards normally do not exceed $150,000 total costs for 1 year.[42]
- **Phase II**. The objective of Phase II is to continue the R/R&D efforts initiated in Phase I. Funding is based on the results achieved in Phase I and the scientific and technical merit and commercial potential of the Phase II project proposed. Only Phase I awardees are eligible for a Phase II award. Both SBIR and STTR Phase II awards normally do not exceed $1,000,000 total costs for 2 years.
- **Phase III**. The objective of Phase III, where appropriate, is for the small business to pursue commercialization objectives resulting from the Phase I/II R/R&D activities. Neither the SBIR nor STTR programs fund Phase III projects. In some federal agencies, Phase III may involve follow-on non-SBIR or non-STTR funded R&D or production contracts for products, processes or services intended for use by the U.S. Government.

It is important to note that grant recipients cannot receive funding for Phase II projects without completing a related and successful Phase I project, and Phase III funding is not available for projects that have not completed a related and successful Phase II project.

Some organizations refer to preparatory work to apply for a Phase I grant as "Phase 0." Phase 0, or the pre-proposal stage, includes the preparatory research showing that an idea is worthy of SBIR or STTR support, research on commercialization potential, and the preparation of capacity within a small firm to perform a research project. Neither the SBIR nor the STTR programs fund this preparatory stage, although there are other programs that may. This topic will be discussed later in this report.

National SBIR / STTR Funding. In 2017, small business across the Nation submitted 22,148 applications for SBIR awards and 3,234 applications for STTR awards. Of these, 5,094 SBIR awards (23.0%) and 847 STTR awards (26.2%) were granted. In total, the federal government awarded almost $2.7 billion in SBIR grant obligations and $369 million in STTR grant obligations. This was a 13 percent increase over 2016 funding.

The majority of these applications were for Phase I support. The SBIR program in total received 19,018 Phase I applications, which made up 86 percent of all applications that year, while the STTR program received 2,820 Phase I applications, or 87 percent of the total. Phase I applications have a much lower acceptance rate than Phase II applications, with only 16.9 percent of Phase I SBIR (3,223) and 21.7

[40] https://www.sbir.gov/performance-benchmarks
[41] https://www.sbir.gov/about/about-sbir
[42] https://www.sbir.gov/about/about-sttr

percent of Phase I STTR (613) applications resulting in an award. As mentioned previously, Phase I projects are funded at a lower level than Phase II, with both SBIR and STTR Phase I projects being funded in 2018 at an average of $192 thousand.

As Phase II awards depend on the completion of a successful Phase I project, it is not surprising that their win rate is much higher. In 2018, 59.8 percent (1,871 of 3,130 applications) of Phase II SBIR projects were funded, while 56.5 percent (234 of 414 applications) of Phase II STTR projects were funded nationwide. These projects received much more funding, with an average obligation of $1 million for SBIR and $970 thousand for STTR Phase II projects in 2017.

Maryland SBIR / STTR Trends. In 2018, Maryland ranked fourth in both the number (247) and total value ($132.9 million) in SBIR awards, after California, Massachusetts, and Virginia. That same year, Maryland ranked ninth in the number of STTR awards received (29, tied with Florida) and seventh in STTR funding ($17.2 million). Note that California and Massachusetts are outliers, receiving significantly more SBIR grant awards than other states (See Figure 24). Maryland has generally ranked fourth in total SBIR grants received between 2014 and 2018 (except in 2015 when it ranked fifth after Colorado).

Figure 24: Top 10 States Receiving SBIR Grants, 2018

State	# of Phase I Awards	# of Phase II Awards	Total Awards	Awards Rank	Total Obligation	Obligation Rank
California	660	338	998	1	$582,637,690	1
Massachusetts	325	201	526	2	$322,137,074	2
Virginia	154	117	271	3	$163,973,324	3
Maryland	173	74	247	4	$132,929,515	4
Colorado	138	95	233	5	$122,500,630	5
New York	136	67	203	6	$115,028,820	7
Pennsylvania	125	74	199	7	$117,178,780	6
Texas	130	67	197	8	$102,192,910	9
Ohio	118	76	194	9	$105,782,008	8
North Carolina	112	46	158	10	$86,781,578	10

Source: SBIR.Gov

When normalizing the number of awards by total population, Maryland still ranks fourth, with one award per every 24,464 residents. Massachusetts ranks first, with one award per every 13,122 residents, with New Hampshire ranking second and Colorado ranking third. California ranks ninth with one award per every 39,636 residents. The national average in 2018 was one award per every 67,625 residents.

In 2018, Maryland ranked ninth in the number of STTR grants received (See Figure 25), and has ranked between fourth and ninth in STTR grants in that time period. Again, when normalized for population, Massachusetts ranks first in STTR grants per population. Maryland's rank improves slightly from ninth to seventh, and California's rank drops to 16th.

Figure 25: Top 10 States Receiving STTR Grants, 2018

State	# of Phase I Awards	# of Phase II Awards	Total Awards	Awards Rank	Total Obligation	Obligation Rank
California	70	34	104	1	$51,866,840	1
Massachusetts	51	22	73	2	$32,016,674	2
Texas	41	13	54	3	$21,780,011	4
Virginia	29	14	43	4	$22,718,018	3
New York	31	9	40	5	$18,046,456	6
Colorado	26	13	39	6	$21,218,986	5
Ohio	28	10	38	7	$16,672,421	8
Pennsylvania	28	10	38	7	$16,598,129	9
Florida	18	11	29	9	$12,448,470	10
Maryland	**20**	**9**	**29**	**9**	**$17,227,631**	**7**

Source: SBIR.Gov

Awards by Phase. By design, there are more awards in Phase I than in Phase II, and Phase I awards are for smaller amounts of money and for shorter durations. This is because Phase I awards are intended to establish the technical merit, feasibility, and commercial potential of an idea, while Phase II awards are continuations of Phase I research that is believed to have technical merit.

It is difficult to use SBIR / STTR statistics to compare Phase II awards to Phase I awards, because each Phase II award is directly related to a Phase I award that was completed in a previous year. However, aggregate statistics show that, on average, the number of Phase II awards is approximately one-third (between 32.3% and 37.3% between 2014 and 2018) of the total number of awards in each year.

Except for 2016, Maryland's percentage of Phase II grant awards has been less than the national average, which may imply that Maryland small businesses are not as successful at creating successful Phase I projects that are then eligible for Phase II funding, and / or do not pursue Phase II funding at the same rate as companies in some other states. Of the top states receiving SBIR and STTR grants, California also has a lower percentage of Phase II grants, while Massachusetts, Virginia, and Colorado generally have higher percentages.

Awards by Agency. In Maryland, the Department of Defense was the largest single source of SBIR/STTR awards (142 awards valued at $40 million). Among all the DoD's branches, the Navy was the largest granter, giving out 44 awards worth nearly $12 million. The Department of Health and Human Services granted 54 awards worth $31 million, and NASA granted 22 worth $7 million.

To give a complete picture of how Maryland performs by agency, an analysis was done that looked at the most recent three years of SBIR and STTR data across the nation. To smooth out any year-to-year variations in award or obligation amounts, the analysis combines SBIR and STTR data together and reviews all three years as one time period to average out any inconsistencies.

Figure 26: Total SBIR and STTR Awards by Agency for the United States, 2016-18

SBIR / STTR Awarding Agency	Total Awards	Total Obligation
Department of Defense	7,328	$ 3,680,547,185
Department of Health and Human Services	4,354	$ 2,936,901,144
Department of Energy	1,635	$ 758,451,647
National Aeronautics and Space Administration (NASA)	1,622	$ 527,888,791
National Science Foundation (NSF)	1,261	$ 563,485,843
Department of Agriculture	338	$ 80,481,418
Department of Commerce	184	$ 38,018,800
Department of Homeland Security	129	$ 52,045,272
Department of Transportation	71	$ 27,967,379
Environmental Protection Agency (EPA)	66	$ 11,783,143
Department of Education	53	$ 23,316,299
TOTAL	17,041	$ 8,701,401,104

Source: SBIR.gov

As Figure 26 shows, the Department of Defense was the largest source of both SBIR / STTR awards and obligations for the 2016-18 time period, with over 7,000 awards and almost $3.7 billion in obligations. The Department of Health and Human Services (DHHS) was second, with over 4,000 awards and $2.9 billion in obligations. In total, the federal government gave out over 17,000 SBIR and STTR awards between 2016 and 2018 worth over $8.7 billion in obligated funds.

Reviewing Maryland's SBIR and STTR awards and related obligations shows that the State attracts more SBIR and STTR investment than would be expected for its population size, which represents 1.8 percent of the total population of the United States. Overall, Maryland attracts 2.6 times the total number of SBIR and STTR grants than would be predicted on a purely per-capita basis, and 2.7 times the amount of funding.

Figure 27: Ratio of Expected vs. Actual Awards and Obligations by State, 2016-18

State	Total Awards	Total Obligation	Awards Rank	Percentage of US Population	Awards Ratio	Obligation Ratio
Massachusetts	1,804	$987,350,977	2	2.1%	5.0	5.4
New Hampshire	246	$118,589,960	19	0.4%	3.5	3.3
Colorado	806	$376,123,937	5	1.7%	2.7	2.5
Maryland	827	$426,646,885	4	1.8%	2.6	2.7
Delaware	125	$64,909,255	28	0.3%	2.5	2.5
Virginia	961	$492,556,931	3	2.6%	2.2	2.2
New Mexico	230	$118,927,286	20	0.6%	2.1	2.1
California	3,501	$1,832,750,222	1	12.1%	1.7	1.7
Montana	88	$35,354,686	32	0.3%	1.6	1.3
Washington, D.C.	58	$26,018,720	35	0.2%	1.6	1.4

Source: SBIR.gov, U.S. Census Bureau, Commerce Calculations.

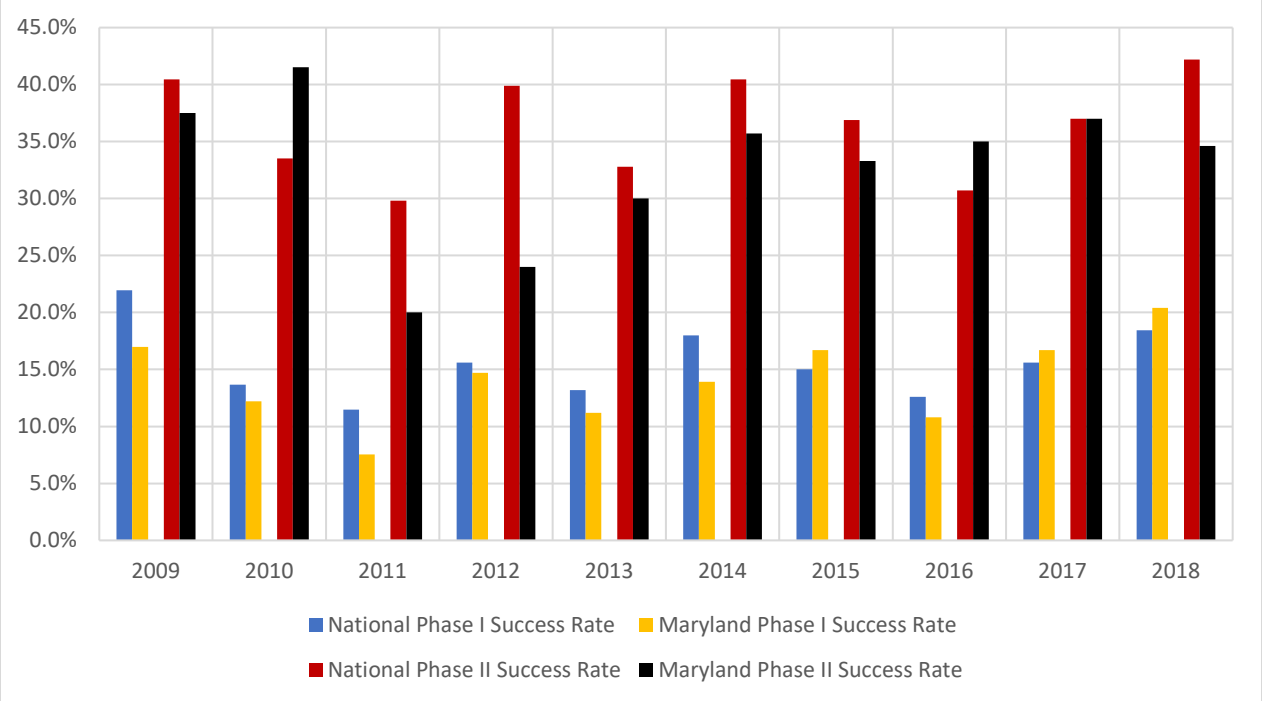
Reviewing total funding award and obligation data for all 50 states and the District of Columbia shows that there are 33 states that underperform in attracting SBIR and STTR awards based on their expected per-capita share. Of those states that attract more than their expected share, Massachusetts ranks the highest, with Maryland ranking fourth. It should be noted that Massachusetts is highly successful at attracting SBIR and STTR awards and funding, doing so at almost twice the rate that Maryland does (See Figure 27).

Note that both the SBIR and STTR programs expend all of their budgeted funding each fiscal year.[43]

Acceptance Rates by Agency and State. Data on the success rates of SBIR and STTR award applications is not uniformly published by agency on the state level. However, there is some information available from different sources, which allows a basic analysis of applications vs awards.

The most complete data is provided by the National Institutes of Health (NIH), which tracks applications and awards by state back to 2009. These data show that the percentage of successful Phase I proposals accepted by NIH from Maryland's small businesses has ranged between 12.6 percent in 2016 and 21.9 percent in 2009 (See Figure 28). Maryland's Phase I success rates for NIH SBIR grants have varied from the overall national rate, in most cases by not more than 2 percent. Phase II success rates are more variable. It should be noted that, while Massachusetts received 60 Phase I awards from NIH in 2018 as compared to Maryland's 41, the Massachusetts success rate was slightly lower than Maryland's (19.9% vs. 20.4%). Massachusetts received 50% more awards because it filed 50% more applications (302 vs. 201).

Figure 28: National and Maryland SBIR Proposal Success Rates to NIH, 2009-18

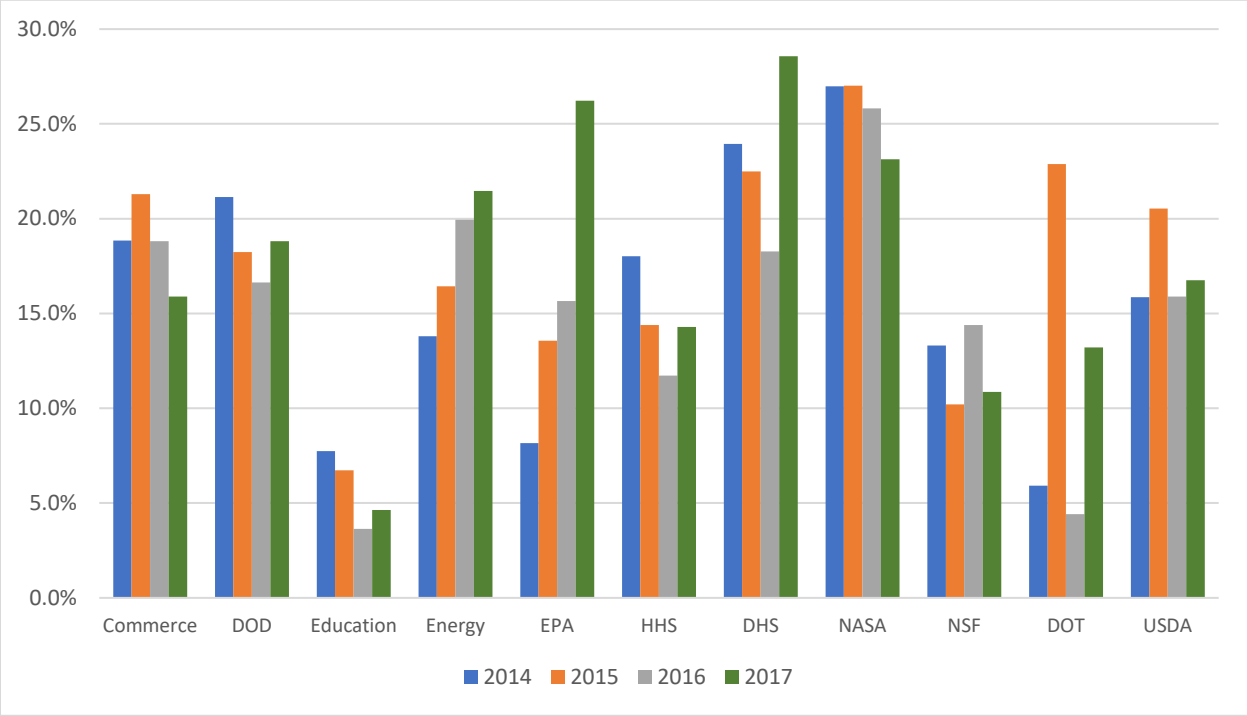


[43] https://www.sbir.gov/sites/default/files/2018%20SBIR%20Road%20Tour_New%20England_Slides.pdf

Source: NIH SMALL BUSINESS INNOVATION RESEARCH (SBIR) AND SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) GRANTS, Competing Applications, Awards, Success Rates and Total Funding, by Phase and State, Made with Direct Budget Authority Funds, Fiscal Years 2009 - 2018 (Table #216)

Note that acceptance rates can vary between agencies. The following chart shows the variation in acceptance rates for SBIR applications by each of the 11 funding agencies between 2014 and 2017. Each agency has at least some variation in acceptance rates, and some (such as Transportation) have large variations (See Figure 29).

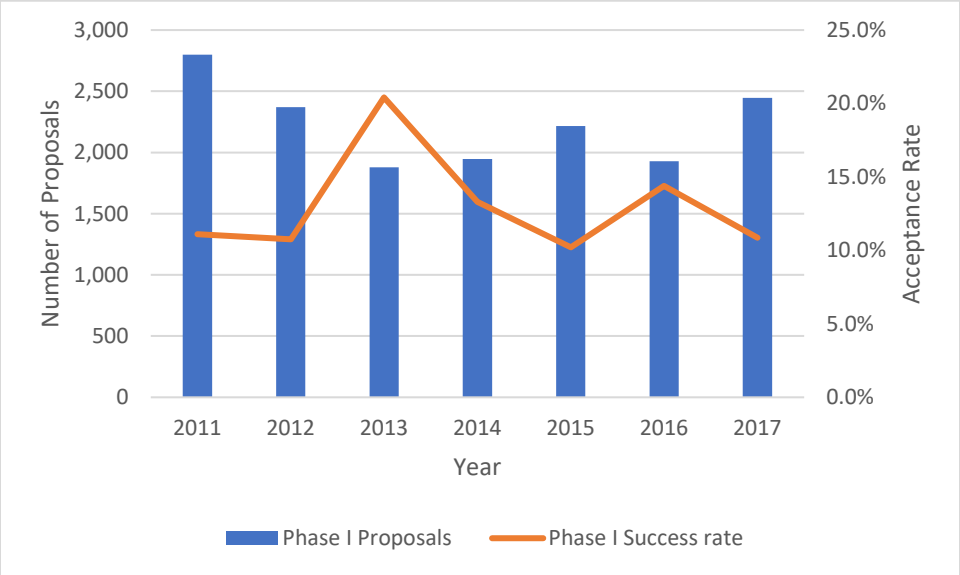
Figure 29: National SBIR Acceptance Rates by Agency, 2014-17



Source: SBIR.gov

There is a relationship between the number of proposals received by an agency and the overall success rate of proposals at that agency. As Figure 30 shows, Phase I success rates at NSF increased in years where the number of proposals decreased, and generally decreased when proposal numbers increased. As the SBIR program has a budget cap for each agency, and is limited to approximately $150,000 per award, there are only so many awards that an agency can give out in a year. An increased number of applications does not increase the number of final awards, but only decreases the overall success rate.

Figure 30: NSF Phase I SBIR Proposals and Acceptance Rates, 2011-17



Source: SBIR.gov

Maryland vs. Massachusetts. Maryland and Massachusetts are national leaders in research, and Massachusetts is often cited as a model for Maryland to follow for commercializing research. However, the primary driver of research in Maryland is the federal government, and in Massachusetts research is driven by its universities. Figure 31 illustrates this difference.

Figure 31: Comparison of Research Activity Indicators in Maryland and Massachusetts

Indicator	Maryland	Massachusetts
Number of Federal Labs	74	7
Percentage of Research Activity Sponsored by the Federal Government	55%	7%
Number of Four Year Colleges and Universities	35	95
Higher Education Enrollment*	364,207	503,508
Population*	6,042,718	6,902,149

*Massachusetts' population is 12.5% higher than Maryland's population; however, higher education enrollment in Massachusetts is 27.6% higher than it is in Maryland.

The fundamental difference in what is driving research in Maryland compared to Massachusetts suggests that what is needed to successfully commercialize technology is also different. The technology transfer offices at federal labs are often understaffed and it takes a very long time to receive patents and licenses. Whereas the technology transfer offices of universities are often much more robust. The Massachusetts Institute of Technology employs fifty-five people in its technology transfer office. In addition to providing thirty-two experts in residence to assist researchers with starting a company, Harvard University also provides entrepreneurs in residence to assist researchers with financing their companies. Universities have a stronger support structure for commercializing technology than federal labs.

Existing Federal Support Programs. The federal government funds multiple programs that claim to assist SBIR and STTR applicants in writing and submitting proposals. Some of these programs are competitively awarded, while others are funded through general appropriations. These programs are:

Federal and State Technology (FAST) Partnership Program. The Federal and State Technology (FAST) Partnership Program is competitively funded by the U. S. Small Business Administration. It "provides one year funding to organizations to execute state/regional programs that increase the number of SBIR/STTR proposals (through outreach and financial support); increase the number of SBIR/STTR awards (through technical assistance and mentoring); and better prepare SBIR/STTR awardees for commercialization success (through technical assistance and mentoring)."[44] The program is designed to "build the SBIR/STTR ecosystem through:

1. Outreach: increase the pipeline of possible applicants (see SBIR authorization language for explicit direction to increase the participation of women, socially/economically disadvantaged individuals, and small businesses in underrepresented areas, typically rural states); and build the capacity of partner organizations and individuals to refer possible SBIR/STTR applicants through train-the-trainer activities.
2. Financial support: make grants or loans to applicants to pay a portion or all of the cost of developing SBIR/STTR proposals, attending relevant conferences, and bridging possible gaps between phases.
3. Technical assistance: encourage the transition from Phase I to II and commercialization of technology developed through SBIR/STTR program funding; and form and or support mentoring networks to provide business advice and counseling."[45]

The Maryland Technology Enterprise Development Corporation (TEDCO) has received funding to operate the FAST program in Maryland for two years in a row. In September 2018, TEDCO was one of 24 national recipients of a $125 thousand grant to operate a FAST program for FY2019. It received another $125 thousand grant for FY 2020.

NSF Innovation Corps (I-Corps™) Program. The National Science Foundation works with VentureWell to administer the National Innovation Network, which offers the Innovation Corps program (I-Corps™) to participating members. The I-Corps™ program "offers select participants from US academic laboratories the opportunity to participate in a special, accelerated version of Stanford University's Lean LaunchPad

[44] FEDERAL AND STATE TECHNOLOGY (FAST) PARTNERSHIP PROGRAM, FY 2018 Funding Opportunity No. FAST-2018-R-0012
[45] Ibid.

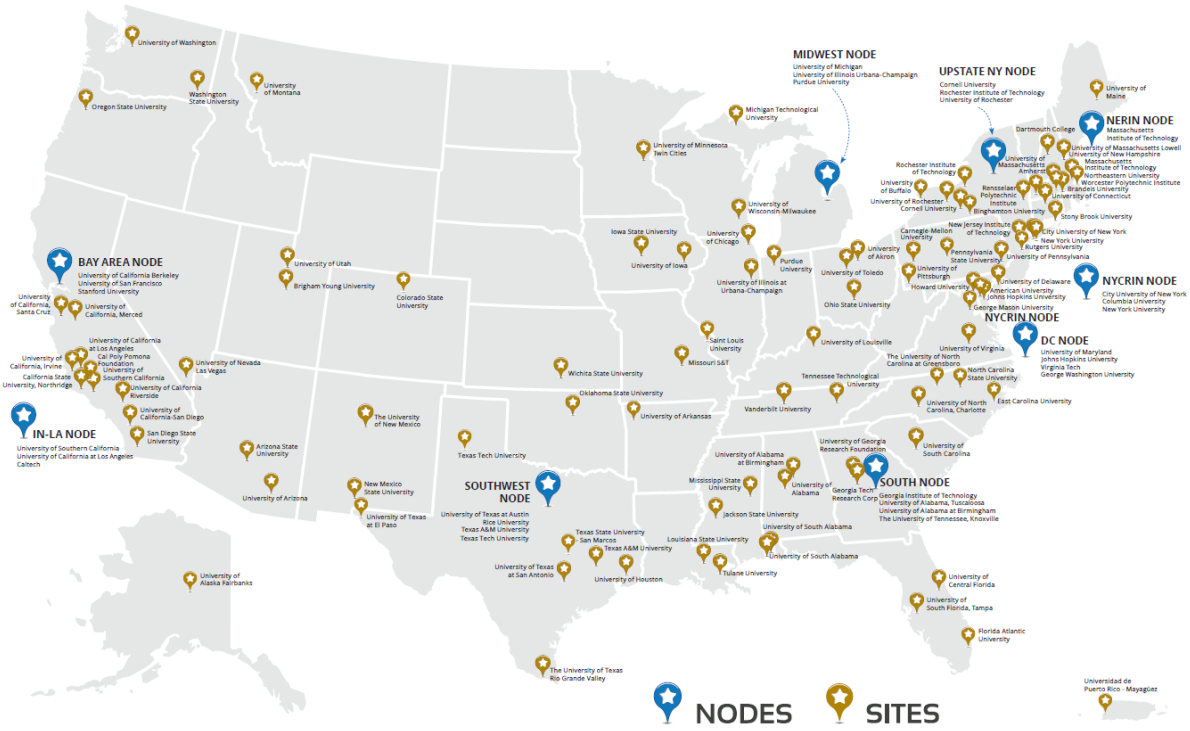
course."[46] Lean LaunchPad "is an entrepreneurship methodology created by Steve Blank to test and develop business models based on querying and learning from customers . . . Students . . . talk with prospective customers and partners, using this customer feedback acquired in these interviews to refine their product or service; ensure their product or service meets a customer need or solves a customer problem; and validate that they have created a repeatable, scalable business model."[47]

NSF I-Corps™ is divided into three layers:

- The I-Corps Team, which consists of a technical lead, an entrepreneurial lead and an I-Corps mentor. These teams go through the I-Corps course together to find out if a new technology is commercializable or not. I-Corps teams may attend an NSF I-Corps training program directly, or may work with the related entities below;
- The I-Corps Sites program, in which eligible academic institutions work with I-Corps Teams to assist them in finding technology concepts that are likely candidates for commercialization. "The make-up of teams at the Sites is modeled after the composition of I-Corps Teams, and training at the Sites shares the principles of the I-Corps Curriculum." These sites "provide infrastructure, advice, resources, networking opportunities, training and modest funding to enable groups to transition their work into the marketplace or into becoming I-Corps Team applicants." There are currently 100 active sites in the United States, one of which is in Maryland at Johns Hopkins University (See Figure 32).
- I-Corps Nodes, which "support regional needs for innovation education, infrastructure and research. The I-Corps Nodes work cooperatively to build, utilize and sustain a national innovation ecosystem that further enhances the development of technologies, products and processes that benefit society. Nodes are single- or multi-institution efforts to support innovation regionally."[48] The Maryland region is a part of the DC I-Corps Node, which is run jointly by Johns Hopkins University, the University of Maryland, and other regional institutions.

[46] https://venturewell.org/i-corps/
[47] https://en.wikipedia.org/wiki/Lean_Launchpad
[48] https://www.nsf.gov/news/special_reports/i-corps/

Figure 32: Location of NSF I-Corps Nodes and Sites, 2019



Source: https://venturewell.org/wp-content/uploads/map1118-1.pdf

Growth Accelerator Fund. This program is funded by the U.S. Small Business Administration and provided $50,000 to 60 of "the nation's most innovative and promising small business accelerators and incubators" totaling $3 million in late 2019 for FY 2020.[49] The fifth year of funding for this program focused on "accelerators that work with high tech entrepreneurs that are potential Small Business Innovation Research (SBIR) or Small Business Tech Transfer (STTR) program applicants (www.sbir.gov). This year's award recipients will focus at least 60 percent of their Competition-related work to entrepreneurs who represent one of the following groups: women; socially and economically disadvantaged individuals; entrepreneurs living in or whose businesses are located and operate in states with a lower number of SBIR/STTR awards, or in an Opportunity Zone."[50]

There were four accelerator programs in Maryland who received $50,000 in funding for FY2020. These were Mtech Ventures in College Park, the F³ Tech Accelerator in Easton, the LifeBridge Health Accelerator Program in Baltimore, and FastForward at Johns Hopkins Technology Ventures, also in Baltimore.

Small Business Development Centers (SBDC). Small Business Development Centers (SBDCs) are partnerships between the U.S. Small Business Administration and local groups such as colleges and universities. They are jointly funded, and have existed in every state since 1990. The Maryland SBDC is

[49] https://www.sba.gov/offices/headquarters/ooi/resources/1428931
[50] Ibid.

based in College Park at the University of Maryland and has five satellite offices, one in each region of the State.

Procurement Technical Assistance Center (PTAC). Procurement Technical Assistance Centers (PTACs) are part of the Procurement Technical Assistance Program, which is administered by the Defense Logistics Agency of the Department of Defense. They provide local, in-person counseling and training services for small business owners. They are "designed to provide technical assistance to businesses that want to sell products and services to federal, state, and/or local governments. PTAC services are available either free of charge, or at a nominal cost."[51] There are more than 300 PTACs across the nation, including one in Maryland (MD PTAC). PTACs are funded through cost sharing cooperative agreements between the Defense Logistics Agency and eligible program participants, including states, local governments and nonprofit organizations.[52]

SBA Regional Innovation Cluster (RIC). The U.S. Small Business Administration (SBA) launched the Regional Innovation Cluster (RIC) Initiative in September 2010. "This initiative promotes and supports industry clusters—geographically concentrated groups of interconnected businesses, suppliers, service providers, and related institutions in a particular industry or field—that have been associated with increased regional economic growth."[53] While there are now 14 Regional Innovation Clusters across the nation, none of them cover Maryland.

EDA Regional Innovation Strategies (RIS) Program. This program is led by the Office of Innovation and Entrepreneurship (OIE), a division of the U.S. Economic Development Agency. The RIS program was originally authorized under the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. § 3722). In its current configuration, it "awards grants that build regional capacity to translate innovations into jobs (1) through proof-of-concept and commercialization assistance to innovators and entrepreneurs and (2) through operational support for organizations that provide essential early-stage risk capital to innovators and entrepreneurs."[54] There are two components to this program: The i6 Challenge, which is designed to "support the creation of centers for innovation and entrepreneurship that increase the rate at which innovations, ideas, intellectual property, and research are translated into products, services, viable companies, and jobs"[55]; and the Seed Fund Support Program, which is designed to provide "funding for technical assistance to support the creation, launch, or expansion of equity-based, cluster-focused seed funds that invest regionally-managed risk capital in regionally-based startups with a potential for high growth."[56] Currently, there are two recipients of funding in Maryland for the i6 Challenge, the Chesapeake Regional Digital Health Exchange (CReDHx) from Johns Hopkins Technology Ventures (JHTV) and the Farm-Fish-Food (F3) Tech Program from the Eastern Shore Entrepreneurship Center (ESEC). Maryland received no awards from the Seed Fund Support Program in FY2019.

Manufacturing Extension Partnership (MEP). The Hollings Manufacturing Extension Partnership (MEP) is based at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD. The MEP National Network comprises the National Institute of Standards and Technology's Manufacturing

[51] https://www.sba.gov/offices/headquarters/ogc/resources/362381
[52] https://www.dla.mil/SmallBusiness/PTAP/
[53] https://www.sba.gov/sites/default/files/aboutsbaarticle/SBAClusters_Year3_Report.pdf
[54] https://www.eda.gov/oie/ris/
[55] Ibid.
[56] Ibid.

Extension Partnership (NIST MEP), 51 MEP Centers located in all 50 states and Puerto Rico, and more than 1,300 manufacturing experts at over 400 service locations.[57] While MEPs exist to serve the needs of the manufacturing industry, they also play a limited role in tech transfer (usually University tech transfer).[58] Maryland's Manufacturing Extension Partnership (MD MEP) is funded by the State of Maryland.

In addition to these resources, each of the eleven SBIR and five STTR awarding agencies has their own SBIR / STTR office that can give assistance to companies looking to apply for awards from that agency.

Existing Support Programs in Maryland.

- *Maryland Defense Technology Commercialization Center*
- *Defense Patent Database*
- *Maryland Procurement Technical Assistance Center (MD PTAC)*
- *Maryland Technology Internship Program (MTIP)*
- *TEDCO Seed Investment Fund*
- *TEDCO Federal and State Technology (FAST) Partnership Program*
- *UM Maryland Industrial Partnerships (MIPS) Program*
- *University of Maryland and University of Baltimore's MPower Program*
- *Johns Hopkins University Technology Ventures (JHTV)*

Discussion of these programs is provided in the Existing Programs section of this report.

In addition to resources listed above, there are SBIR/STTR-specific resources available to Maryland's small businesses. Some examples are:

- *DC I-Corps Program*. The DC I-Corps Program is a "regional program designed to foster, grow and nurture an innovation ecosystem in the nation's capital, the nearby states of Maryland and Virginia, and the mid-Atlantic region. The program is sponsored by the National Science Foundation (NSF) and jointly run by the University of Maryland College Park, George Washington University, Virginia Tech, and Johns Hopkins University. The program provides real world, hands-on training on how to successfully incorporate innovations into successful products. The ultimate goal is to create a new venture or licensing opportunity for program participants."[59]
- *Montgomery County SBIR/STTR Matching Grant Programs*. Started in 2018, Montgomery County's Matching Grant Programs grant eligible companies receiving an SBIR or STTR Phase I grant a match of 25 percent up to a maximum of $25,000, and those receiving an SBIR/STTR Phase II a match of 25 percent up to a maximum of $75,000. The program is first-come, first-served, and only companies receiving SBIR or STTR awards from the National Institutes of Health and performing at least 51 percent of eligible R&D activities within Montgomery County are eligible for this program. The program was initially funded at $425 thousand, which resulted in 12 grants, nine for Phase I awards and three for Phase II awards.

[57] https://www.nist.gov/mep/about-nist-mep
[58] https://fas.org/sgp/crs/misc/R44308.pdf
[59] http://www.dcicorps.org/what-is-dc-i-corps/

(2) study the laws and regulations of other states governing financial assistance programs for SBIR/STTR grant recipients

Various states offer financial assistance programs for small businesses pursuing SBIR or STTR funding. Various programs offer assistance for companies in Phase 0, Phase I, or Phase II.

Phase 0 Support. According to the Small Business Administration, "At last count, 23 states had a formal Phase 0 program. In addition to Phase 0 assistance, most states offer other kinds of information and guidance regarding the SBIR and STTR programs. These organizations include Small Business Development Centers (SBDCs), Departments of Economic Development, Procurement Technical Assistance Centers (PTACs), and universities. For universities, the relevant department can be the Technology Transfer Office, the Research and Economic Development Office, an incubator, or an innovation center."[60] There are too many programs to list across many states that offer Phase 0 support to small business. Often this support takes the shape of grant writing assistance and business planning.

Phase I and Phase II Matching Grant Support. There are 16 programs in 15 states that offer matching grant programs for SBIR and STTR awardees to help them reach the commercialization stage. These programs approach SBIR and STTR support differently:

- Of the 16 programs, 11 are competitively funded, while three are first-come, first-served based on the order in which applications are received. The remaining two (Hawaii and North Carolina) operate on a first-come, first-served basis unless they are oversubscribed, at which time the relevant agency can choose to review applications in a different manner.
- Programs in Hawaii and Massachusetts are the only states whose programs specifically mention funding opportunities for Phase III commercialization projects
- The Florida High Tech Corridor Council requires grant recipients to partner with a Florida university to receive funding, which gives Florida universities control over which projects are funded.
- Five programs explicitly state that awardees must be performing research that falls into certain pre-defined areas of study. For example, the MassRamp program from Massachusetts is only for Life Science companies, while the Kentucky program requires projects to be within one of the State's five strategic focus areas.
- Some programs restrict funding use to areas such as activites not covered by federal grant funds, additional funding if federal funding is not sufficient to complete the project, or to expand the scope if the expansion uses the same technology.
- One unique program is the SBIR Targeted Technologies (START) program, offered by MassVentures of Massachusetts. Each year, the programs awards ten (10) "Stage I" grants of $100,000 each, five (5) "Stage II" grants of $200,000 each to the most promising "Stage I" winners from last year, and two (2) "Stage III" opportunities: up to $500,000 each of seed capital in a commercial spinout (or other commercial arrangement intended to provide a return on investment to MassVentures) from the most successful Stage II companies. A new crop of Stage I candidates every year perpetuates the cycle.
- Some programs have strict limits on participation. For example, Tennessee states that no individual company can receive match funding totaling more than $150,000, companies older than 10 years

[60] https://www.sbir.gov/sites/all/themes/sbir/dawnbreaker/img/documents/Course15-Tutorial1.pdf

are limited to two matches every two years, and that the total number of matches any company can receive in its lifetime is six. Virginia only allows one application per company per year, and limits the number of grants that can be given to any company to five SBIR awards for Phase I funding and 8 for Phase II funding. Virginia also limits grant support to companies with fewer than 12 employees.

Figure 33: Matrix of State-Level SBIR/STTR Grant Programs

State	Organization	Phase	Value	Requirements
Florida	Florida High Tech Corridor Council	Phase II	$10,000 to $150,000	• $3 to $1 Match • Requires university collaboration • Funding is competitive
Hawaii	Hawaii Technology Development Corporation	Phase I Phase II & III	50% of Grant Up to $500,000	In case of funding shortfall: • Preference given to first-time SBIR/STTR recipients • Limit of one grant per Phase II or III award • Preference given to I-Corps graduates
Iowa	Iowa Innovation Corporation	Phase I	Up to $50,000	• Proposal ideas must be reviewed before acceptance • Proposal writing assistance is available • Funding is competitive
Kentucky	KY Innovation, Kentucky Cabinet for Economic Development	Phase I Phase II	Up to $150,000 Up to $500,000	• Proposal topic must be within on of State's five strategic focus areas • KY Innovation will take an equity stake in the firm • Funding is competitive
Maine	Maine Technology Institute	Phase I & II	Up to $50,000	• Proposal topic must be within one of State's seven strategic focus areas • Company must pass review to qualify for funding • Funding is competitive
Massachusetts	MassRamp, Massachusetts Life Sciences Center	Phase I	$75,000 to $300,000	• Proposal topic must be related to life sciences • Funding must be used for certain purposes • Company cannot have applied for a related Phase II grant • Funding is competitive
Massachusetts	SBIR Targeted Technologies ("START") Program, MassVentures	Phase I Phase II Phase III	10 companies each receive $100,000 5 Phase I companies receive $200,000 2 Phase II companies receive $500,000 in seed capital	• Phase II and III companies must be part of a previous cohort of Phase I companies • Companies receiving FDA approval are not eligible, must apply to MassRamp • Phase III requires that companies to provide an equity stake to MassVentures • Funding is competitive

State	Organization	Phase	Value	Requirements
Michigan	Michigan Emerging Technologies Fund (ETF)	Phase I Phase II	Up to $25,000 Up to $125,000	• Proposal topic must be within one of ETF's four supported technology sectors • Firm must remain in Michigan for 5 years after receipt of funding • Firm cannot have received more than two Phase II awards • Funds are first-come, first-served
Montana	Montana Department of Commerce	Phase I & II	Up to $60,000	• No more than one application per company per year • Funds are first-come, first-served
Nebraska		Phase 0 Phase I & II	Up to $5,000 Up to 65%, not to exceed $100,000	• Phase 0 funds support proposals • No more than one application per project every two years • Funding is competitive
North Carolina	One North Carolina Small Business Program	Phase I	Up to 50%, not to exceed $65,000	• No more than one application per firm per year • Funds are usually first-come, first-served, however, in case of funding shortfalls other selection methods may be used
Rhode Island	Innovate Rhode Island Small Business Fund	Phase 0 Phase I Phase II	Up to $3,000 Up to $45,000 Up to $100,000	• A $3,000 grant to support internships at SBIR / STTR firms is also offered • Funding is competitive
South Carolina	South Carolina Research Authority	Phase I	Up to 50%, not to exceed $50,000	• Limit of two awards over company lifetime • No more than one application per firm per year • Can only be used to cover costs not allowed under SBIR/STTR rules OR to bring project to Phase II status • Funding is competitive
Tennessee	Launch Tennessee	Phase I Phase II Phase I & II	50% match in Tier 1&2 Counties 65% match in Tier 3&4 Counties 25% match Limit of $150,000 per year per company	• Limit of 6 awards over company lifetime • Multiple applications per company allowed • Must stay in TN for 24 months after award • Funds are first-come, first-served
Virginia	Commonwealth Research Commercialization Fund (CRCF), Center for Innovative Technology	Phase I or II	Up to $50,000 to be used to fill gaps not supported by the federal award	• One application per company per year • Limit of 5 SBIR awards for Phase I funding, 8 for Phase II • Maximum 11 employees in firm • No more than 2 previous State awards • Funding is competitive
Wisconsin	SBIR Advance, Center for Technology Commercialization	Phase I Phase II	Up to $75,000 or 50 percent Up to $100,000 per year for up to two years	• Preference given to first-time awardees • Companies with more than three SBIR/STTR Phase 2 awards are not eligible • Lean Startup training required • Funding is competitive

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(3) make recommendations regarding financing options for recipients of federal small business innovation research grants and small business technology transfer grants

Conclusions

Whether it is through federal labs, or SBIR and STTR grants, federally sponsored research is a primary driver of research activity in Maryland. This research activity alone provides an economic benefit to Maryland with the research jobs it provides. However, federally sponsored research does not always translate to developing commercial products. That is partially because the nature of the research that is conducted, and barriers to commercializing federal research that exist.

The federal government often sponsors research aimed at answering "big" questions, or that seeks to add to the cannon of scientific knowledge. From 1990 to 2003, the federal government invested $3.8 billion in the Human Genome Project. While the knowledge gained from this research laid a foundation for developing commercial products in medicine, agriculture, and even information technology, the product of this research in and of itself cannot be commercialized. In 2013, the Supreme Court ruled that human genes cannot be patented because the discovery of a product of nature does not create anything new, so there is no intellectual property to protect. The Human Genome Project is an excellent example of federally sponsored research that may not have an immediate commercial application, but makes further research that may have a commercial application possible.

Almost half of the SBIR and STTR grants awarded to Maryland are awarded by the Department of Defense (DoD), which sponsors very unique research to meet its very specific needs. Although the DoD has awarded more than twice the number of SBIR or STTR grants than any other federal agency, the research it sponsors leads to only about five or six patents per state per year. Having awarded a total of 83,380 SBIR and STTR grants since the inception of the programs, the intellectual property that is patented represents only approximately 5% to 8% of all research sponsored by the DoD.

In addition to the type of research that is conducted by federal labs, the technology transfer offices of federal labs are often understaffed, which causes long delays in obtaining patents and licenses. There are also varying degrees of emphasis on technology transfer among federal labs. One of the stakeholders consulted by Commerce stated that some federal labs do a decent job with technology transfers, but some lab directors see tech transfers as "a waste of time."

(1)(i) explore ways to foster job creation and economic development in the State by capitalizing on the federal presence in the State;

Maryland communities and companies already do an excellent job leveraging the federal presence in the State. The high rankings that the State receives in federal intramural research expenditures (1), federal research expenditures through FFRDCs (8), federal support for academic research (3) and private business research (2), as well as funding for non-profit research institutes (4) demonstrate that Maryland's businesses and universities are adept at receiving Federal investment and support.

Maryland's long history of support for the State's federal presence means that many State tax credit, grant, and technical assistance programs have been created to support Maryland businesses in their journey to become federal contractors, and to assist current federal contractors in growing and

diversifying their businesses. However, there is always room for improvement. In the next sections of this report, issues surrounding technology transfer from federal research laboratories and improvements in applying for research grants from the SBIR / STTR program will be examined. These are areas where changes in federal policy and better coordination between State actors could improve Maryland's economic outcomes.

(1)(ii) explore ways to encourage small businesses to engage in federal research and development that has the potential for commercialization;

The State of Maryland has numerous programs that are designed to assist Maryland's small businesses in engaging in the federal procurement process. In FY2019, small businesses received almost $1 billion in federal contract appropriations (including SBIR / STTR awards) to perform research and development activities in Maryland. Almost 40 percent of this contract funding was through the Department of Defense.

National-level data on small business research shows that most research is performed by large businesses, who have been increasing their spending over the past decade. Small businesses, conversely, expend a relatively small amount of the nation's total research funding and have seen decreases in their overall research spending over time.

Changes on the federal level will make it easier for small businesses to receive tax credit support and to have their federal involvement in contracting activity tracked. The Federal Research Tax Credit, the major federal tax credit program that supports research spending, was modified in 2015 to better support the needs of small business. These changes allow small businesses to claim R&D expenses that were otherwise difficult or impossible to claim before the changes. In addition, regulatory change are underway that should make it easier for small businesses who are lower-tier subcontractors to have their contributions to federal contracts reported.

Finally, Maryland does have multiple programs that support both small businesses who are or want to be federal contractors and small businesses who are involved in research and development activities. However, the sheer variety of these programs may be a major stumbling block for many small businesses in understanding and taking advantage of them. Recommendation #2 would have the State create a more robust process for performing outreach and education to ensure that small businesses would have the knowledge they need to take advantage of federal opportunities in Maryland.

(1)(iii) explore ways to facilitate the transfer of technology from small businesses; and

The world of technology transfer is complex. There have been many attempts over time to make it easier for private businesses to transfer technologies from federal and university research into commercial settings. However, while there are now many resources and programs available to assist private business in transferring technology, these resources and programs can be difficult to understand and require a great deal of time and investment.

To assist private companies with the tech transfer process, the federal government chartered the FLC to be a central resource. The State of Maryland has itself created resources to assist in this endeavor, such as the DefTech program and Defense Patent Database from the Department of Commerce, tech transfer assistance from TEDCO, and programs run by both the University System of Maryland and Johns Hopkins.

The challenge for small business is to make these numerous and complex programs available in ways that support firms with limited resources. For example, while a large firm may be able to afford to pay an employee to become a visiting scientist at a federal lab, a small firm may struggle with this expense.

(1)(iv) explore ways to encourage small businesses to apply for federal small business innovation research grants and small business technology transfer grants;

Success rates for Phase I SBIR proposals ranged from 4.6 percent (DOE) to 28.6 percent (DHS) in 2017 (See Figure 29). This means that between 71.4 and 95.4 percent of all proposals were rejected, depending on the program and agency. These failure rates represent a great deal of effort on the part of applicants that did not result in funding.

Success rates vary from year to year, partly because the number of applications varies. The SBIR and STTR programs both have finite funding budgets, and increasing the number of applications will not necessarily increase the number of final awards. However, Massachusetts has had the most success in attracting SBIR and STTR funding, not because the State sees higher success rates for its applications, but because its small businesses submit a larger number of applications than those in other states. This demonstrates that a higher volume of applications can result in more awards, as long as those applications are of competitive quality.

The federal landscape for applying for SBIR and STTR funding is complex and difficult for the uninitiated to navigate. In addition, working with all of the various entities and institutions in Maryland that could assist small businesses is difficult, because there is no central point of entry that can guide companies to the resources that they need.

Small businesses applying for SBIR and STTR funding often have issues with obtaining funding that can be used to support company operations. These small firms can fall victim to the "valley of death," "the span of time from the moment [a startup firm] receives its initial capital contribution until it finally begins generating revenue. During this window, it can be difficult for firms to raise additional financing since their business model has not yet been proven."[61] These issues can be exacerbated by federal rules that may limit the amount of profit, overhead, and categories of spending that SBIR or STTR funding can be used for.

Listening Session Findings

The Department of Commerce held two stakeholder listening sessions to gather information for this report, one on August 27, 2019, the other on October 15, 2019. A list of attendees at each listening session can be found in Appendix B of this report. Below is a synopsis of the findings of these sessions, separated into issues facing small businesses applying for SBIR and STTR awards and issues facing institutions wishing to assist small businesses in their pursuit of SBIR and STTR funding.

[61] https://www.investopedia.com/terms/d/death-valley-curve.asp

Small Business Issues	Potential Solutions
Small Company Administration and Management Issues. Companies who are attempting to become SBIR and STTR grant or contract recipients often have issues with finding and paying for company administration and management, especially if they are new. To be successful, new companies need experienced management. However, the short length of a Phase I SBIR project (six months) and the small amount of money available from the program limit these firm's ability to attract experienced managers.	• Executive Recruitment Programs • Grant Funding
Indirect and Unallowable Costs. SBIR and STTR funding agencies have differing rules on how overhead is calculated on SBIR and STR grants or contracts. Some may not allow certain costs, such as Internal Research and Development (IR&D), to be a part of the SBIR/STTR budget at all, while others may cap indirect costs at a percentage of direct costs. These limitations affect how a company can pay for its internal administrative processes.	• Administrative Assistance from Incubators or Accelerators • Grant Funding to cover costs not covered by SBIR or STTR funding
Insufficient Understanding of the Commercialization Process. Many companies cannot create winning SBIR or STTR applications because they have an insufficient understanding of the commercialization process. This lack of understanding translates into an inability to set clear goals for their research projects and an inability to demonstrate a clear path to the creation of a commercializable product.	• Training programs • Business plan assistance • SBIR / STTR Application Drafting Assistance • Greater statewide implementation of iCorps™ or similar program
Lack of Understanding of the SBIR and STTR Programs. In addition to lacking understanding of commercialization, many small companies do not understand the differences between the various SBIR and STTR programs and how to best navigate those differences. In addition, companies do not understand how best to structure and phase their research programs to maximize their ability to receive funding from the SBIR or STTR programs. For example, a company may be better off breaking one complex project into multiple, simpler projects that are better suited for the time frame and funding level of the Phase I award process, then combining the results of these multiple projects into one Phase II project that could lead to a commercializable end result.	• Training programs • Business plan assistance • SBIR / STTR Application Drafting Assistance
Funding Programs Should Be Competitive. Funding scarcity means that it is unlikely that all of Maryland's SBIR and STTR recipients could receive funding assistance. Any program that offers direct financial assistance to companies pursuing SBIR or STTR awards should be competitively funded. Because both the SBIR and STTR programs are based on technology commercialization, the competitive review should focus on the technology to be commercialized, the quality of the business plan, and the ability of the small business to achieve its goals.	• Any direct assistance program should be competitively funded, and should require review of a company's commercialization prospects and business plan

Small Business Issues	Potential Solutions
Any Funding Program Should be Coupled to Education. Listening session participants have found that simply offering funding to companies without ensuring that they have the internal capability to use that funding appropriately can lead to funds being wasted.	• Couple any funding assistance to the completion of I-Corps, FAST, or similar programs

Institutional Issues	Potential Solutions
Lack of Consistency in SBIR / STTR Support. While various institutions in Maryland give support to companies going after SBIR or STTR awards, the quality of this assistance can be variable.	• Cooperation between institutions to create consistent assistance and messaging • Training for Tech Transfer staff at Universities and Federal Laboratories
Multiple Points of Contact Cause Confusion. Related to the above, it can be difficult for a firm to know which federal laboratory or educational institution is the best one to contact to receive assistance or to tap intellectual property. A successful example of this model is the Texas Medical Center, which is a single portal that leads to 54 separate medical and research institutions in Texas. Once a potential client or collaborator enters through this single point of contact, they are directed to the best institution for their need.	• Create and fund a single point of contact for Maryland SBIR / STTR applicant assistance
Lack of Funding for SBIR / STTR Technical Assistance. While the University of Maryland, Johns Hopkins University, and TEDCO have all received funding and assistance from both NSF (I-Corps program) and SBA (FAST grant funding), this funding has been intermittent and limited in scope and duration, meaning that assistance programs have must restrict the number of participant and limit durations.	• Consistent funding for a Maryland-based I-Corps / FAST – type program • A funding volume large enough to offer services to all companies that request assistance
Need for Co-Location of Private-Sector, Academic, and Federal Researchers. Maryland lacks physical spaces where private-sector, academic, and federal researchers can work together in close proximity to perform research, development, and commercialization activities.	• Create and fund co-location spaces in conjunction with academic, federal, and private-sector partners

Recommendations

Recommendation #1: Coordinate with Congressional Delegation for Improvements to the Technology Transfer Process. Develop and implement a formal process for communicating with Maryland's Congressional delegation on federal issues affecting research and development and the commercialization of technology in Maryland. A formal communication process will provide a means to advocate for an increase in funding for federal research, and raise awareness about barriers to commercializing federally funded research.

In 2018, the Maryland Technology Transfer Summit was collaboratively hosted by: the Hogan Administration; U.S. Senators Ben Cardin and Christopher Van Hollen; the Maryland Department of Commerce; and the National Institute of Standards and Technology (NIST). As a result of the summit, a green paper identifying issues with commercializing technologies was drafted by NIST in consultation with Commerce that made a series of recommendations to improve the commercialization of technology. For example, the green paper recommended reforming federal conflict of interest statutes, policies, and agency practices to make it easier for federal researchers to participate in technology commercialization. A full list of these recommendations can be found in the Existing Programs section of this report.

The Maryland Technology Transfer Summit highlighted the fact that some barriers to commercializing technology can only be resolved at the federal level, and illustrated the need to have a formal process to communicate with the State's Congressional delegation on such issues.

Recommendation #2: Tech Transfer Portal. Create a single point of entry for Maryland businesses to take advantage of all of the State's multiple tech transfer assistance and resources. This portal would be web-based and would collect and organize all of the resources listed in the Existing Programs section of this report to ensure that Maryland businesses have the information they need to locate both assistance and transferrable technologies.

Recommendation #3: Collaboration with Federal and State Partners. Collaborate with appropriate partners and service providers in Maryland to create new, or expand existing, programs and events that offer opportunities for Maryland's small businesses to network with federal researchers and clinicians, learn about federal resources for small businesses, discuss regulations for new products and access federal technologies available for licensing. These programs increase the connectivity between investigators, technology transfer professionals, and Maryland's industry, which is essential for the transfer of technology from the federal laboratories to the private sector.

At the Maryland Innovation and Technology Series: Neurotechnology, for example, Maryland's industry and academic sectors were invited to learn about the technologies available for licensing from the National Institute of Mental Health and the National Institute of Neuroscience and Neurological Disorders. This was an event co-sponsored by the Maryland Department of Commerce and the NIST which also provided networking opportunities for researchers and companies in the neurology therapeutic space. These opportunities at the program fostered the collaboration between the industry and NIH investigators in the form of Cooperative R&D agreements (CRADAs), Material Transfer Agreements and Non-exclusive Patent Licenses. Similarly, at the National Cancer Institute's Annual Technology Showcase, in Frederick, the industry was invited to learn about cancer-targeting

technologies primed for commercialization and the programs at the NCI's Office of Technology Transfer that are a resource for researchers and entrepreneurs.

The Maryland Innovation and Technology Series will continue to program around therapeutic areas that are of interest to Maryland's biotechnology and medical device sectors such as autoimmune disorders, surgical innovations, oncology and infectious diseases. Each of these events will incorporate the institutes at the NIH which conduct research in the same area to continue to grow the relationship between Maryland's innovators and the NIH.

Recommendation #4: SBIR/STTR "Phase 0" Commercialization Training and Application Assistance. Explore creating a statewide I-Corps™ program, and SBIR/STTR "Phase 0" application assistance program, potentially through partnerships between State agencies and the State's research universities. A two-stage implementation process is recommended with the first stage being the implementation of the I-CORP training program, and the second stage being the implementation of a SBIR/STTR application assistance program.

Step One: I-Corps™ Training. The goal of this program is to provide I-Corps™ training to 100 private sector and university researchers a year with training cohorts provided on a quarterly basis. Each participating organization may identify up to 5 researchers to participate in training per quarter. A list of private sector researchers who wished to participate in I-Corps™ training would be maintained by the program. In the event a participating organization was unable to identify 5 researchers for quarterly training, other participating organizations could make recommendations to fill the empty training slots. The location of training would rotate between participating organizations each quarter.

Step Two: SBIR/STTR Application Assistance. Upon the successful implementation of the I-Corps™ training program, the organizational partnership would be expanded to provide "Phase 0" SBIR/STTR application assistance for qualifying small businesses and researchers.

Recommendation #5: Encourage the Creation of a Statewide Association of Technology Transfer Offices. Encourage Maryland's institutions to join together and create a Maryland statewide organization of Technology Transfer Offices, based on the model of the national Association of University Technology Managers (AUTM) and the Massachusetts Association of Technology Transfer Offices (MATTO). Like MATTO, this organization would "promote efficient and effective transfer of knowledge and technology developed at academic institutions . . . to companies that will develop and bring novel products to market for the public good."[62] As of 2019, 31 institutions belong to MATTO, who employ over 200 professionals in their offices of technology transfer. A Maryland version of this organization would allow Maryland's tech transfer professionals to network, share information, implement training programs, and otherwise improve the effectiveness of tech transfer staff across the State.

Recommendation # 6: Support and Increase Awareness of Federal Programs and Partnerships. Support and increase awareness of federal programs that augment the recommendations of this report. This includes:

- Increasing the awareness and formation of Cooperative Research & Development Agreements between Maryland businesses and federal laboratories. Supporting the

[62] http://www.mttc.org/matto/

creation of Entrepreneurial Leave programs, and Entrepreneur-in-Residence programs by local federal laboratories to develop the business skillsets of scientists commercializing a technology in Maryland. These entrepreneurial programs augment the fourth recommendation, SBIR/STTR Commercialization Training and Application Assistance, by providing the opportunity of federal researchers to take advantage of the recommended State programs, and fosters the intent of the recommendation by helping researchers obtain the business skills necessary to commercialize technology.

- Increasing the awareness of Strategic Partnership programs, Use Facilities Agreements and Visiting Scientist Programs to increase the utilization of federal laboratory expertise and equipment by Maryland small businesses. Increasing awareness can be done through the first and second recommendations of this report which are: Coordinate with Congressional Delegation; and the Tech Transfer Portal.

Recommendation #7: Examine the Creation of a State SBIR/STTR Matching Grant Program After the Implementation of a State I-Corp Progam and SBIR/STTR Application Assistance Program. Researchers frequently do not have the skillset or adequate knowledge of how to run a business, or navigate the federal SBIR/STTR process. Providing researchers the opportunity to obtain the necessary skills and knowledge through an I-Corp progam, and SBIR/STTR application assistance program, will help to maximize the potential value of State SBIR/STTR grants. Therefore, a State matching grant program should be examined after a State I-Corp program and SBIR/STTR application assistance program are implemented and evaluated for their effectiveness.

In examining the creation of a State SBIR/STTR matching grant program, consideration should be given to: awarding grants competitively and providing preference to applicants who have completed I-Corps training; making the grant program for small businesses; requiring companies to stay in Maryland for a defined period; allowing State funds to be used for expenses not allowed under federal SBIR grants, such as administrative expenses; and limiting grant awards to individual companies to prevent "SBIR mills."

Appendix A: Study Criteria

Chapter 306 of 2019 set forth the requirement for the Maryland Department of Commerce to create a Small Business Innovation Research and Technology Transfer Study. The relevant portion of the Chapter is below.

SECTION 1. BE IT ENACTED BY THE GENERAL ASSEMBLY OF MARYLAND,

That:

(a) The Department of Commerce shall:

(1) explore ways to:

(i) foster job creation and economic development in the State by capitalizing on the federal presence in the State;

(ii) encourage small businesses to engage in federal research and development that has the potential for commercialization;

(iii) facilitate the transfer of technology from small businesses; and

(iv) encourage small businesses to apply for federal small business innovation research grants and small business technology transfer grants;

(2) study the laws and regulations of other states governing financial assistance programs for recipients of federal small business innovation research grants and small business technology transfer grants; and

(3) make recommendations regarding financing options for recipients of federal small business innovation research grants and small business technology transfer grants.

(b) On or before December 31, 2019, the Department of Commerce shall submit its findings and recommendations to the General Assembly, in accordance with § 2–1246 of the State Government Article.

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Appendix B: Listening Session Attendance

Listening Session One: August 27, 2019

Attendee Name	Title	Organization
Emma Bigelow	SBIR Grant Consultant and Start-Up Advisor	Lakewood Bio
Ernesto Chanona	Office of BioHealth & Life Sciences	Dept. of Commerce
Gary Evans	Executive Director	DefTech Maryland
Heather Gramm	Senior Director of Strategic Industries and Entrepreneurship	Dept. of Commerce
James Palma	Senior Research Manager	Dept. of Commerce
Jennifer LaHatte	Business Policy Analyst	Dept. of Commerce
Malachy Rice	Regulations Analyst	Dept. of Commerce
Neil Davis	Director, Entrepreneurial Development	TEDCO
Rhonda Ray	Managing Director Policy, Research and Government Affairs	Dept. of Commerce

Listening Session Two: October 15, 2019

Name	Title	Organization
Adam Van Dyke	Senior Associate	Early Charm Ventures
Alex Hamann	Assistant Director Policy, Research & Government Affairs	Dept. of Commerce
Andrew Flannery		Pathsensors, Inc
Anita Nosratieh	Senior Advisor for Innovation Payer Communication Task Force and CDRH Innovation	FDA-Center for Devices and Radiologic Health
Bob Storey	Managing Partner	The MVR Company
Elizabeth Burger	Senior Director of Strategic Initiatives	John Hopkins Tech Ventures
Ernesto Chanona	Office of BioHealth & Life Sciences	Dept. of Commerce
Heather Gramm	Senior Director - Office of Business & Industry Sector Development	Dept. of Commerce
James Palma	Senior Research Manager	Dept. of Commerce
Jay Perman	President	University of Maryland, Baltimore
Jody Sprinkle	Director Government Affairs	TEDCO
Kristin Bircsak	Manager, US Research Team	Mimetas US, Inc
Lily Qi	Delegate	Maryland House of Delegates
Lindsay D'Ambrosio Ryan	Venture Development Director	USM-Columbus Center
Mary Morris	Director-Baltimore Fund	UMVentures, University of Baltimore
Mary Clapsaddle	Director, Sate Affairs	John Hopkins Tech Ventures
Peter McGinnity	Finance Department	Montgomery County Government

Name	Title	Organization
Steve Auvil	Executive vice President, Operations & Programs	TEDCO
Steve Silverman	CEO	SS Gov Relations, LLC
Tom Sadowski	Vice Chancellor for Economic Development	USM- Office of Economic Development

Appendix C: Technology Transfer Resources in Maryland

Technology Organizations in Maryland

Name	Description	Web site
Statewide		
Maryland Technology Development Corporation	Fosters growth of tech economy statewide, particularly incubator development, tech transfer and electronic commerce.	www.tedcomd.com
Maryland Tech Council (MTC)	Develops linkages among tech industry public sector partners; strengthens area's tech workforce; encourages entrepreneurship; advocates for a "tech-friendly" business environment and public awareness of tech significance.	mdtechcouncil.com
Regional / County		
Carroll Technology Council	Works to advance technology growth in Carroll County.	www.carrolltechcouncil.org
Charles County Technology Council	Acts as a cooperative alliance to advance people, technology and ideas in Charles County.	www.thetechcouncil.net
Howard Tech Council	Forum for networking and collaboration between tech companies in Howard County and the surrounding region.	www.hceda.org/business-support/htc
Northeastern Maryland Technology Council (NMTC)	Regional partnership to advance technology environment and understanding of impact for economy in Harford and Cecil counties.	www.nmtc.org
The Patuxent Partnership	Alliance of regional partners to advance tech environment and broader economy of area.	www.paxpartnership.org

Maryland's Tech Transfer Programs:

Maryland Technology Development Corporation (TEDCO)
www.tedcomd.com
(410) 740-9442 / (800) 305-5556
TEDCO brings innovations from universities and federal labs into the state's economy by facilitating the transfer of technology to the private sector and by providing emerging technology companies and university researchers with vital seed funding and specialized technical assistance.

Maryland Technology Enterprise Institute (MTECH)
mtech.umd.edu
(301) 405-3906
The Maryland Technology Enterprise Institute (MTECH), a unit of the A. James Clark School of Engineering at the University of Maryland, accelerates new ventures, spurs economic growth, and brings university expertise to Maryland companies through technology entrepreneurship and research programs.

Business Incubators in Maryland:

Maryland is home to more than 30 business incubators, with more in the planning stages.

Statewide Incubator Resources
Maryland Technology Development Corporation (TEDCO)
www.tedcomd.com
(410) 740-9442
(800) 305-5556

The goal of TEDCO's business incubator assistance program is to promote the growth of technology companies in the State of Maryland through support of business incubators. Since its inception in 2001, TEDCO has been instrumental in building the incubation network in Maryland to become the most comprehensive and cohesive in the country. This includes a variety of support services available to the incubators and their companies.

Maryland Business Innovation Association (MBIA)
www.incubatemaryland.org
The Maryland Business Innovation Association (MBIA) is an association of business incubators dedicated to sharing resources, information, and best practices among the members with the overall goal of promoting business incubation excellence within all Maryland's incubators. Through leveraging individual resources, MBIA is able to provide a complete package of valuable business and technical assistance to start-up companies in Maryland, even when certain skills and talent are not available locally. Through sharing information and best practices, MBIA is able to assure a high level of quality within these best of breed incubators.
Technology Organizations
Maryland has made a priority of providing technology resources to Maryland companies. From the transfer of new technologies to business applications to providing workforce solutions for growing technology companies, Maryland has it all.

Tech Transfer Offices at Federal Institutions

Aberdeen Proving Ground
Army Test and Evaluation Command, Business Management Division
www.atec.army.mil/
(443) 861-9369

Aberdeen Proving Ground
Army Edgewood Chemical Biological Center, Technical Industrial Liaison Officer
www.ecbc.army.mil/about/sbir_sttr.html
(410) 436-4438

Army Research Laboratory, Adelphi
Small Business Innovation and Research Program
www.arl.army.mil/technologyoutreach
(301) 394-4808

Naval Surface Warfare Center, Carderock
Small Business Office
www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Carderock/Partnerships/Small-Business-Office/
(215) 897-7596

Naval Air Station Patuxent River
Office of Naval Research – Small Business Innovation and Research Program
www.navysbir.com
(703) 696-0342

Naval Support Facility, Indian Head
Office of Naval Research – Small Business Innovation and Research Program
www.navysbir.com
(703) 696-0342

Goddard Space Flight Center (GSFC)
Strategic Partnerships Office
partnerships.gsfc.nasa.gov/index.html
(301) 286-5810

National Institutes of Health (NIH)
Small Business Innovation Research Program
sbir.nih.gov
(301) 435-2688

National Institute of Standards and Technology (NIST)
Small Business Innovation and Research Program
www.nist.gov/tpo/sbir/index.cfm
(301) 975-4188

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Appendix D: Federal Laboratories in Maryland

#	Name	Agency	County	Type
1	USDA Agricultural Research Service (ARS) - Northeast Area	Department of Agriculture	Prince George's	Intramural
2	National Institute of Standards and Technology - NIST	Department of Commerce	Montgomery	Intramural
3	DOD DISA - Joint Interoperability Test Command (JITC)	Department of Defense	Charles	Intramural
4	DOD Uniformed Services University of the Health Services (USUHS)	Department of Defense	Montgomery	Intramural
5	NIH Clinical Center at the National Institutes of Health (NIH)	Department of Health and Human Services	Montgomery	Intramural
6	Frederick National Laboratory for Cancer Research (FFRDC)	Department of Health and Human Services	Frederick	FFRDC
7	DHS Chemical Security Analysis Center (CSAC)	Department of Homeland Security	Harford	Intramural
8	DHS National Biodefense Analysis and Countermeasures Center (NBACC)	Department of Homeland Security	Frederick	Intramural
9	Aberdeen Test Center (ATC)	Department of the Army	Harford	Intramural
10	Army Research Laboratory (ARL) - Aberdeen Proving Ground Site - CCDC	Department of the Army	Harford	Intramural
11	Army Research Laboratory (ARL) - Adelphi Site - CCDC	Department of the Army	Harford	Intramural
12	CCDC - C5ISR Center - COMMAND, POWER & INTEGRATION DIRECTORATE - CP&I	Department of the Army	Harford	Intramural
13	CCDC - C5ISR Center - Intelligence and Information Warfare Directorate	Department of the Army	Harford	Intramural
14	CCDC - C5ISR Center - Product Realization Engineering & Quality Directorate	Department of the Army	Harford	Intramural
15	CCDC - C5ISR Center - Software Engineering Directorate	Department of the Army	Harford	Intramural
16	CCDC - C5ISR Center - Space and Terrestrial Communications Directorate	Department of the Army	Harford	Intramural
17	U.S. Army Center for Environmental Health Research	Department of the Army	Frederick	Intramural
18	U.S. Army Clinical Investigation Regulatory Office	Department of the Army	Frederick	Intramural
19	U.S. Army Combat Capabilities Development Command Chemical Biological Center	Department of the Army	Harford	Intramural
20	U.S. Army Developmental Test Command (DTC)	Department of the Army	Harford	Intramural
21	U.S. Army Medical Research and Development Command (USAMRDC)	Department of the Army	Frederick	Intramural
22	U.S. Army Medical Research Institute of Chemical Defense (USAMRICD)	Department of the Army	Harford	Intramural
23	U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID)	Department of the Army	Frederick	Intramural

#	Name	Agency	County	Type
24	USAMRMC - Telemedicine and Advanced Technology Research Center	Department of the Army	Frederick	Intramural
25	Walter Reed Army Institute of Research (WRAIR)	Department of the Army	Montgomery	Intramural
26	Naval Air Warfare Center (NAWC) - Aircraft Division - Patuxent River	Department of the Navy	Saint Mary's	Intramural
27	Naval Explosive Ordnance Disposal Technology Division	Department of the Navy	Charles	Intramural
28	Naval Medical Research Center	Department of the Navy	Montgomery	Intramural
29	Naval Surface Warfare Center (NSWC) - Carderock Division	Department of the Navy	Montgomery	Intramural
30	Naval Surface Warfare Center (NSWC) - Indian Head Explosive Ordnance Disposal Technology Division	Department of the Navy	Charles	Intramural
31	United States Naval Academy	Department of the Navy	Anne Arundel	Intramural
32	EPA - Environmental Protection Laboratories	Environmental Protection Agency	Anne Arundel	Intramural
33	NASA Goddard Space Flight Center	National Aeronautics and Space Administration	Prince George's	Intramural
34	NIH Center for Information Technology (CIT)	National Institutes of Health	Montgomery	Intramural
35	NIH Fogarty International Center (FICNIH)	National Institutes of Health	Montgomery	Intramural
36	National Center for Advancing Translational Sciences (NCATS)	National Institutes of Health	Montgomery	Intramural
37	National Center for Complementary and Alternative Medicine (NCCAM)	National Institutes of Health	Montgomery	Intramural
38	National Eye Institute (NEI)	National Institutes of Health	Montgomery	Intramural
39	National Heart, Lung, and Blood Institute (NHLBI)	National Institutes of Health	Montgomery	Intramural
40	National Institute of Allergy and Infectious Diseases (NIAID)	National Institutes of Health	Montgomery	Intramural
41	National Institute of Arthritis and Musculoskeletal and Skin Diseases	National Institutes of Health	Montgomery	Intramural
42	National Institute of Biomedical Imaging and Bioengineering (NIBIB)	National Institutes of Health	Montgomery	Intramural
43	National Institute of Dental and Craniofacial Research	National Institutes of Health	Montgomery	Intramural
44	National Institute of Diabetes and Digestive and Kidney Diseases	National Institutes of Health	Montgomery	Intramural
45	National Institute of General Medical Sciences	National Institutes of Health	Montgomery	Intramural
46	National Institute of Mental Health	National Institutes of Health	Montgomery	Intramural
47	National Institute of Nursing Research	National Institutes of Health	Montgomery	Intramural
48	National Institute on Aging	National Institutes of Health	Montgomery	Intramural
49	National Institute on Deafness and Other Communication Disorders	National Institutes of Health	Montgomery	Intramural
50	National Institute on Drug Abuse	National Institutes of Health	Montgomery	Intramural
51	National Institutes of Health	National Institutes of Health	Montgomery	Intramural
52	National Library of Medicine	National Institutes of Health	Montgomery	Intramural
53	NIH Office of Research Services (ORS)	National Institutes of Health	Montgomery	Intramural

#	Name	Agency	County	Type
54	NOAA Air Resources Laboratory	National Oceanic and Atmospheric Administration	Prince George's	Intramural
55	NOAA Air Resources Laboratory Atmospheric Sciences Modeling Division (ASMD)	National Oceanic and Atmospheric Administration	Prince George's	Intramural
56	NOAA Center for Coastal Monitoring and Assessment	National Oceanic and Atmospheric Administration	Montgomery	Intramural
57	NOAA Meterological Development Laboratory	National Oceanic and Atmospheric Administration	Montgomery	Intramural
58	NOAA National Centers for Coastal Ocean Science (NCCOS)	National Oceanic and Atmospheric Administration	Montgomery	Intramural
59	NOAA National Centers for Environmental Prediction	National Oceanic and Atmospheric Administration	Prince George's	Intramural
60	NOAA National Oceanic Data Center	National Oceanic and Atmospheric Administration	Montgomery	Intramural
61	NOAA Office of Aquaculture	National Oceanic and Atmospheric Administration	Montgomery	Intramural
62	NSF Institute for Systems Research (ISR) - NSF Engineering Research Center at UMD	National Science Foundation	Prince George's	Intramural
63	NSA Technology Transfer Program	National Security Agency	Anne Arundel	Intramural
64	FDA Center for Drug Evaluation and Research (CDER)	U.S. Food and Drug Administration	Montgomery	Intramural
65	FDA Center for Tobacco Products (CTP)	U.S. Food and Drug Administration	Montgomery	Intramural
66	FDA Center for Veterinary Medicine (CVM)	U.S. Food and Drug Administration	Prince George's	Intramural
67	FDA Office of Regulatory Affairs (ORA)	U.S. Food and Drug Administration	Montgomery	Intramural
68	U.S. Food and Drug Administration (FDA)	U.S. Food and Drug Administration	Montgomery	Intramural
69	FDA Center for Biologics Evaluation and Research (CBER)	U.S. Food and Drug Administration	Montgomery	Intramural
70	FDA Center for Devices and Radiological Health (CDRH)	U.S. Food and Drug Administration	Montgomery	Intramural

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Appendix E: Detailed Research Expenditures in Maryland

Figure 34: R&D Expenditures, Top 10 States, by Performing Sector and Source of Funds, 2016
(Millions of current dollars)

State	All R&D	All R&D Rank	Federal Intramural	FFRDCs	Business	Academic	Nonprofit
California	135,129	1	2,246	5,393	117,569	8,889	859
Massachusetts	28,941	2	397	1,626	21,560	3,797	343
Texas	23,431	3	681	9	17,353	5,257	424
New York	23,212	4	236	579	15,714	6,090	499
Washington State	22,902	5	200	915	19,673	1,646	132
Michigan	21,803	6	448	0	18,847	2,468	98
Maryland	21,730	7	11,013	830	5,676	3,800	182
New Jersey	17,564	8	581	82	15,715	1,158	64
Illinois	17,495	9	245	1,057	13,733	2,401	158
Pennsylvania	17,420	10	704	146	12,300	3,951	215

Source: NSF

Figure 35: Maryland R&D Expenditures, by Performing Sector and Source of Funds, 2012-2016
(Millions of current dollars)

Year	Total R&D Spending	Total R&D rank	Federal Intramural Spending	FFRDCs*	Business**	Higher Education	Other Nonprofit Institutions	State, Internal
2012	18,354	4	10,137	461	4,028	3,368	359	1
2013	19,105	4	10,057	481	4,770	3,451	345	1
2014	20,211	5	10,618	549	5,124	3,573	345	1
2015	20,385	5	10,462	702	5,136	3,742	342	1
2016	21,730	7	11,013	830	5,676	3,800	411	1

*Reported FFRDC expenditures may include administrative costs
**Business expenditures may exclude data on R&D activities that could not be located by state
Source: National Patterns of R&D Resources, National Science Foundation, 2019

Note that between 2012 and 2016 Maryland's rank fell from fourth to seventh place. In 2012, total R&D spending in Maryland was exceeded by only three states: California (1), Massachusetts, (2), and Texas (3). In 2016, that list expanded to include New York (4), Washington State (5), and Michigan, with the total difference between fourth and seventh place in 2016 being $1.5 billion (6.7%). New York moved into fourth place due to a strong increase in the amount of business-funded R&D, which increased from $11.7 to $15.7 billion in just five years.

In 2016, all of Maryland's research sectors received a total of $17 billion in federal funding for research. This represented almost 79 percent of the total funds expended in Maryland on research and development. For comparison purposes, the national average is only 23 percent.

Figure 36: Federal R&D Expenditures in Maryland, by Performing Sector, 2016
(Millions of current dollars)

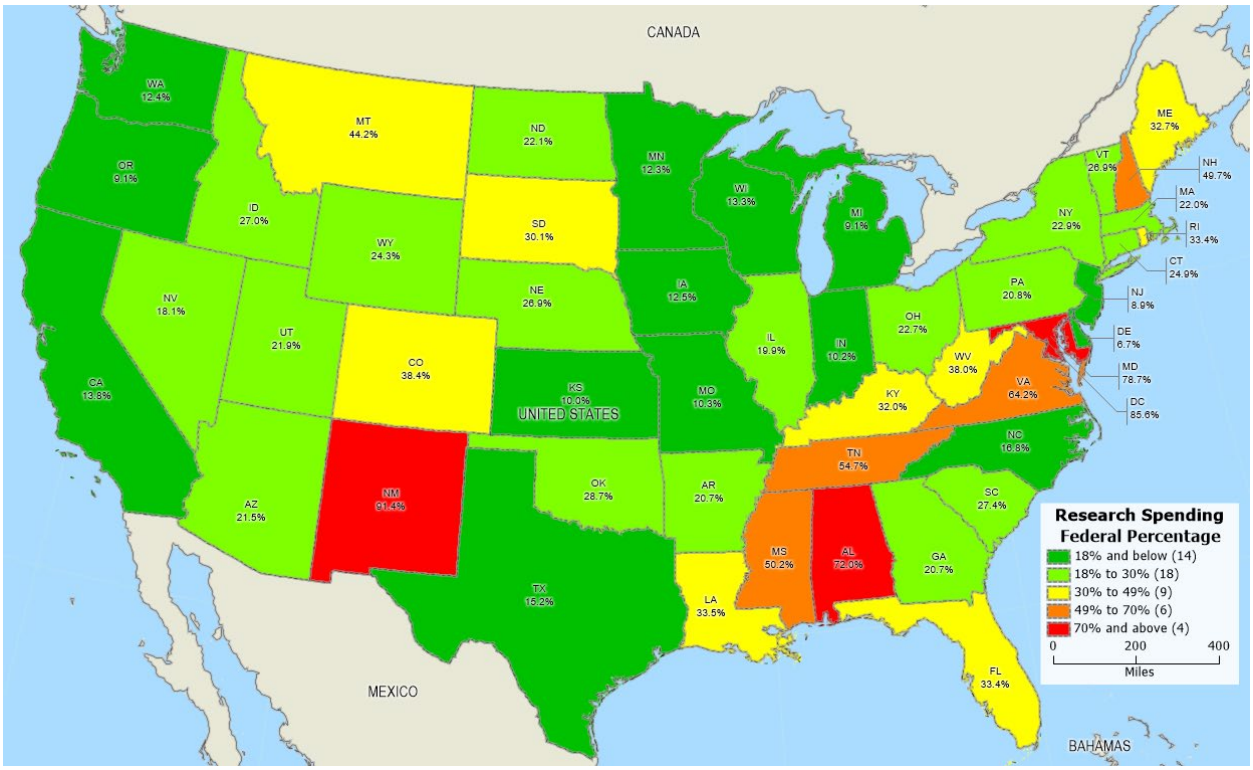
Performing Sector	Federal Funds Expended	Federal Expenditure Rank	Percent of Total Funds Expended	Percentage Rank
Federal Intramural	$11,013	1	100.0%	-
FFRDC	$830	8	100.0%	*
Business	$1,877	2	33.1%	3
Higher Education	$2,963	3	78.0%	1
Other Non-Profit	$411	4	100.0%	**
Total R&D, All Sectors	$17,094	2	78.7%	3

* The federal government is the source for the vast majority of all FFRDC funds

** NSF does not collect data on total non-federal R&D expenditures for the Other Non-Profit Sector

Source: National Patterns of R&D Resources, National Science Foundation, 2019

Figure 37: Percentage of Total R&D Expenditures from Federal Sources by State, 2016



Source: National Patterns of R&D Resources, National Science Foundation, 2019

As Figure 37 above shows, R&D funding from federal sources was responsible for less than 30 percent of all R&D expenditures in most states in 2016. Federal R&D funding made up more than 70 percent of all R&D funding in only four states: New Mexico (91.4%), the District of Columbia (85.6%), Maryland (78.7%), and Alabama (72.0%).

Appendix F: A Short History of Federal Research and Development

The federal government has a long history of funding research and development, predating the existence of the Republic itself. However, consistent and large-scale investments in federal R&D did not occur until after World War II.

The first federal R&D facility was arguably the Springfield Armory in Springfield, Massachusetts. Founded in 1777, it initially was an armory only, but that changed over time as it became a manufacturer of firearms and invested in research and development to improve quality and production processes. Industrial historians credit the Armory with the creation of mass production methods (including the assembly line). The technological advances in production process and metallurgy transferred to the private sector in and around Springfield, making the region a central location for high technology manufacturing for decades. Unfortunately, in the 1960's the U.S. Army decided that funding the Armory was unnecessary as private industry could fulfill the arms design role more efficiently, and it was closed in 1968. After the closure, the Springfield region saw massive disinvestment in high-tech manufacturing industries from the 1960's until the present.

Maryland itself has been a major location for federal R&D for over a century. In 1910, the USDA founded the Henry A. Wallace Beltsville Agricultural Research Center to perform agricultural research, a mission it still has today. The National Bureau of Standards (now NIST) was founded in 1901, and one of its first tasks was to assist in creating standards for fire hose connections in the wake of the Great Baltimore Fire of 1904.[63] (NIST moved to its current home in Gaithersburg in the mid 1960's.) The National Institute of Health, which had its beginnings in the Marine Hospital Service (founded in 1798) and the subsequent Public Health Service, was moved to Bethesda, Maryland in the late 1930's. This coincided with the creation of the National Cancer Institute in 1937.[64] This concentration of health-related research facilities has helped to make the Montgomery County region one of the epicenters of health and biotechnology research in the United States.

Defense research also has a long history in Maryland. The Aberdeen Proving Ground (APG) was established by order of President Woodrow Wilson on October 20, 1917, 6 months after the United States entered World War I and officially opened in December 1917.[65] Also founded in the same area was the former Edgewood Arsenal, also developed in 1917 as a chemical weapons, research, development and testing facility. APG and Edgewood were merged in 1971. Naval Air Station Patuxent River was created in 1942 to "centralize widely dispersed air testing facilities established during the pre-World War II years" and today is one of the Navy's major warfare centers. Both of these facilities have spurred investment in R&D and manufacturing activities in their respective regions.

Research spending increased during World War II, with the creation of what are now called University Affiliated Research Centers (UARCs), which are strategic United States Department of Defense (DoD) research centers associated with a university. The Johns Hopkins University Applied Physics Laboratory

[63] https://www.nextgov.com/cybersecurity/2017/11/commerce-department-standards-agency-has-grown-cybersecurity-powerhouse/142327/

[64] Rowberg, R. 1998. Federal R&D Funding: A Concise History. CRS Report for Congress, Received through the CRS Web, p CRS-3.

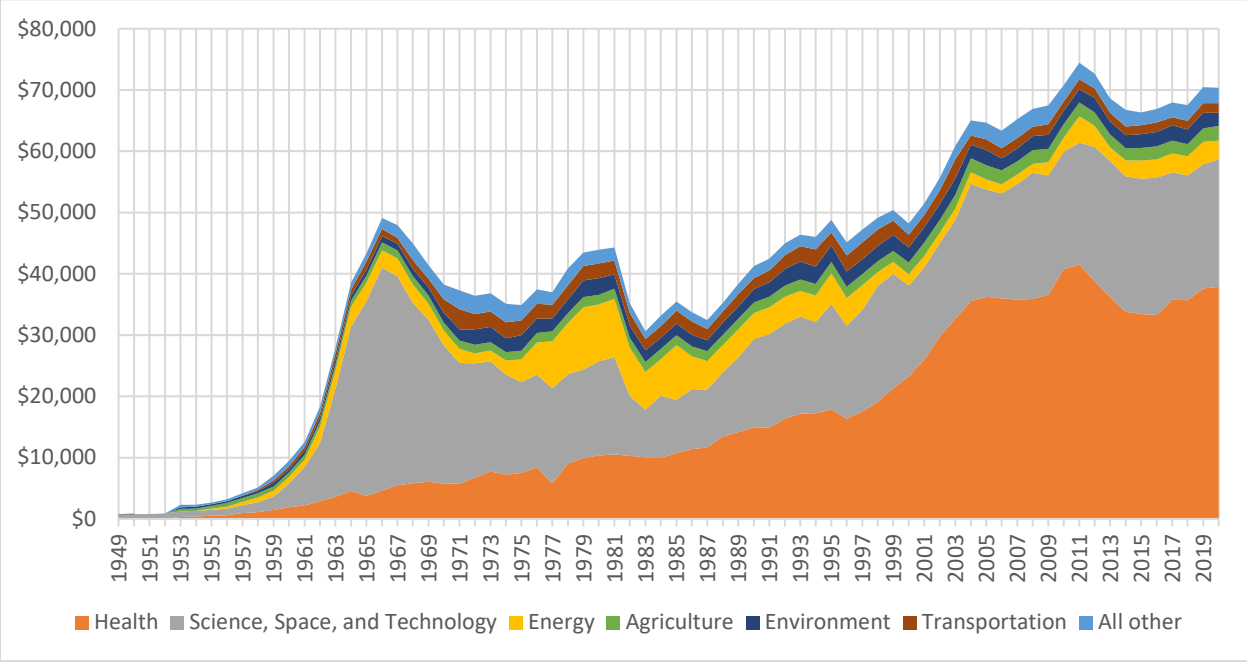
[65] https://www.harfordcountymd.gov/1225/APG-History

(APL) was the first of these, created by the U.S. Navy in 1942 to engage in research supporting the war effort.

After World War II, the United States chose to sustain its investments in science, research, and development, and has seen large increases in spending in these areas. Measured in constant 2019 dollars, U.S. R&D spending has increased by almost 1,400 percent, from $9 billion to $134.6 billion.[66] The largest constant dollar increase has been seen in defense-related research, which has increased from $6.5 billion in 1949 to an estimated $64.3 billion in 2020.[67] The largest percentage increase in federal R&D spending was been in health-related R&D, which increased from $353 million in 1953 (the earliest year on record) to an estimated $37.9 billion in 2020, a 10,627 percent increase (See Figure 38 and Figure 39).

Note that some spending priorities wax and wane over time. Spending on Science, Space, and Technology peaked in 1966 at an inflation-adjusted $36.4 billion, driven mostly by NASA's inflation-adjusted $33.1 billion budget during the height of the space program. Spending in that R&D category then decreased until it hit a low of $7.8 billion in 1983. In 2020 it will have increased back to an estimated $20.8 billion, half of which will be spent by NASA.

Figure 38: Federal Outlays for Civilian Research and Development: 1949 – 2020
In Constant Millions of 2019 Dollars

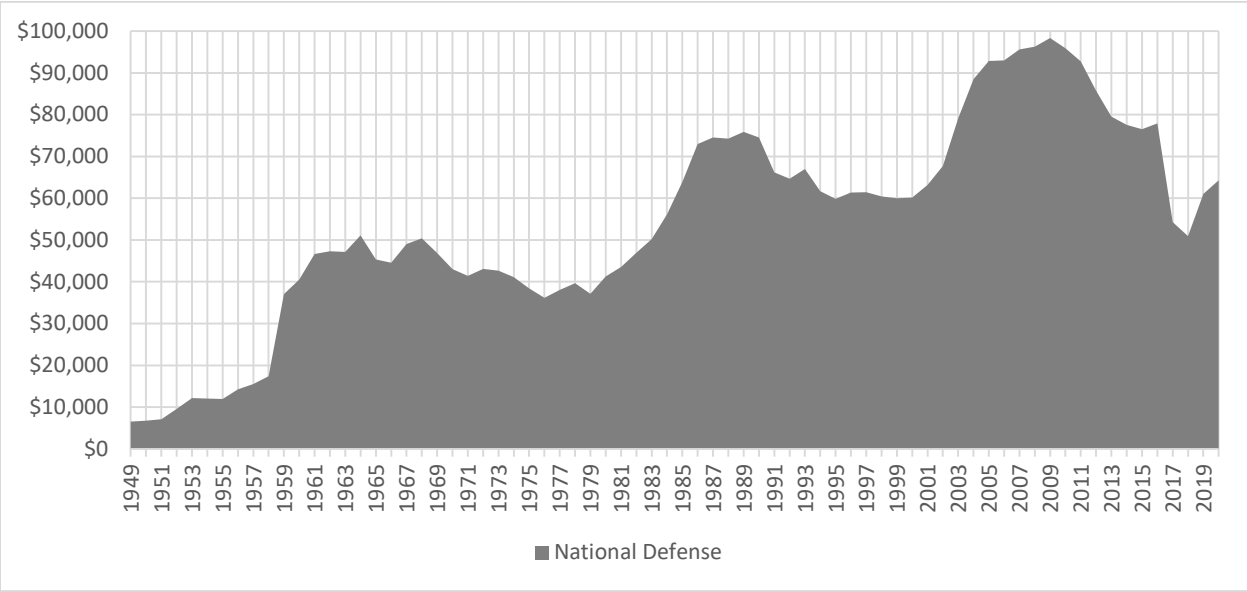


Source: Historical Tables, Office of Management and Budget, 2019

[66] Historical Table 9.8—Composition of Outlays for the Conduct of Research and Development: 1949–2020, Office of Management and Budget, 2019

[67] While Figure 39 shows that defense-related research spending peaked in 2009 at $98 billion in constant 2019 dollars, it should be noted that about $25 billion in defense-related R&D expenditures were reclassified as capital expenditures in 2017, meaning that the drop from 2009 to 2019 was not as severe as it looks.

Figure 39: Federal Outlays for Defense Research and Development: 1949 – 2020
In Constant Millions of 2019 Dollars



Note: The reduction in outlays for defense research and development from 2016 to 2017 is due in part to a redefinition of categories, as certain defense outlays formerly classified as research and development were reclassified as acquisition of major equipment as of 2017. The amounts reclassified were $27.0 billion in budget authority and $24.5 billion in outlays.
Source: Historical Tables, Office of Management and Budget, 2019

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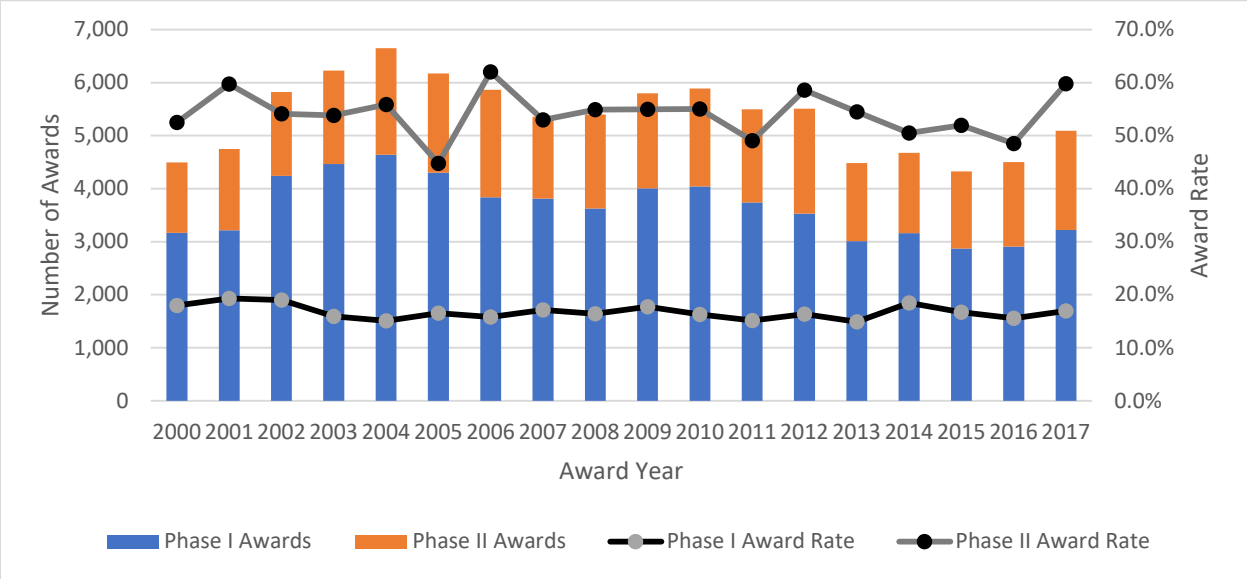
Appendix G: SBIR and STTR Award Numbers and Success Rates, 2000-17

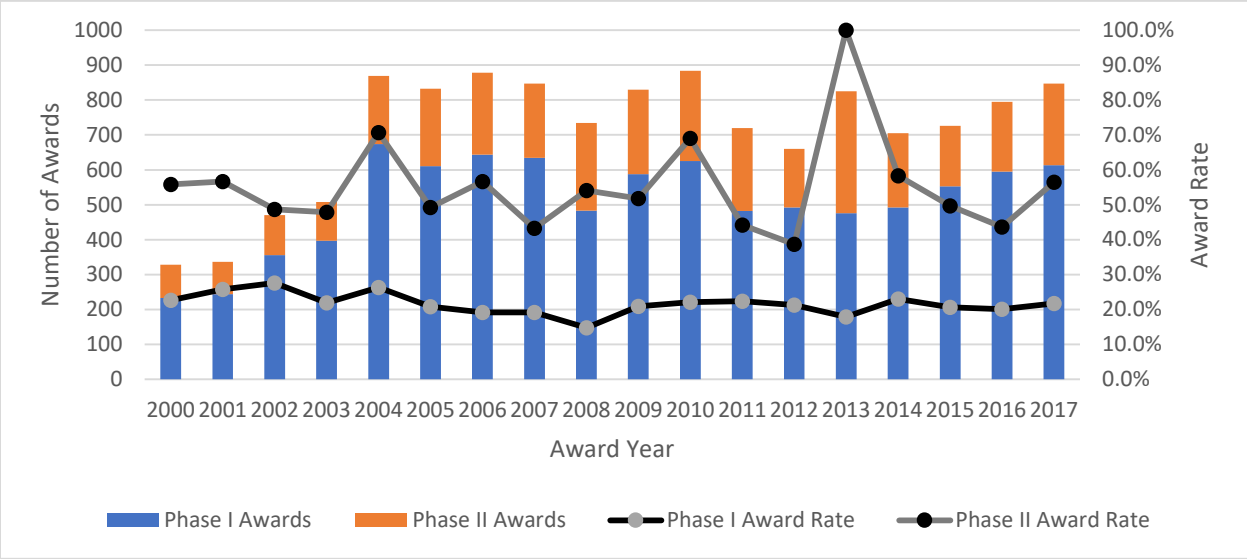
A review of the number of Phase I and Phase II awards for each program since 2000, along with Phase I and Phase II award rates, can be found in Figure 40 and Figure 41. It shows that the Phase I acceptance rate is generally between 15 percent and 20 percent, while there is more variation in the Phase II rate.

Figure 40: Number of Awards and Award Rates for Phase I and Phase II SBIR Awards, United States, 2000-17



Source: SBIR.gov

Figure 41: Number of Awards and Award Rates for Phase I and Phase II STTR Awards, United States, 2000-17



Source: SBIR.gov

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