1156 15th St NW
Suite 502
Washington, DC 20005
www.sbtc.org

SBTC
Small Business Technology Council

July 30, 2018

Dr. Courtney Silverthorn
Deputy Director, Technology Partnerships Office
National Institute of Standards and Technology
100 Bureau Drive MS 2201
Gaithersburg, MD 20899
301-975-4189
courtney.silverthorn@nist.gov
roi@nist.gov
https://www.nist.gov/tpo/roi-rfi-response

Subject: SBTC RFI Response: Federal Technology Transfer Authorities and Processes

Document Citation: 83 FR 19052

Dear Dr. Silverthorn:

The Small Business Technology Council (www.SBTC.org) is writing to express our comments on the subject NIST Request for Information published in 83 Federal Register 19052, Docket Number: 180220199-819-01

The Small Business Technology Council (SBTC) is the nation's largest association of small, technology-based companies in diverse fields. SBTC is a council of the National Small Business Association (www.NSBA.biz) which is the nation's first small-business advocacy organization. NSBA is a staunchly nonpartisan organization with 65,000 members in every state and every industry in the U.S. SBTC advocates on behalf of the 6000 firms who participate in the Small Business Innovation Research (SBIR) program and its sister Small Business Technology Transfer (STTR) program. These two programs receive a very small portion of the Federal R&D budget, but their impact on Federal technology transition is outsized. With less than 1.7% percent of Federal R&D, SBIR/STTR firms have created over 20 percent of America's major innovations, and about as many patents as all universities combined,[1] plus we are creating sustainable manufacturing and service jobs in the U.S. By these programs' design, they unleash the ingenuity, energies and entrepreneurship of American small business, and comprise a remarkably powerful Federal program in transitioning Federal R&D to the American economy. The Federal government should implement policies to remove current Federal barriers to greater success while boosting the overall effort of this successful innovation program.

[1] Innovation Development Institute LLC., Swampscot, MA, https://www.inknowvation.com/sbir/analytics

Introduction

Certain facts about innovation and job creation are generally recognized:

1. Small business is the innovation and job creating engine for the US economy.
2. The Government is not doing enough for small business and restrains its effectiveness, especially in R&D and innovation.
3. Other countries are now investing far more than the US in small business support for R&D.
4. Improvements in innovation and job creation will come if small business is given more support and if government barriers are reduced.
5. The SBIR program works. It funds research that ends up creating innovations that go to the marketplace and create jobs.
6. SBIR is the only R&D program with a proven economic impact of at least 17 to 1.[2]

America is falling behind on innovation

1. EU spends more than 4 times as much money, over 20% of their R&D budget, with small business than the US does at less than 5%.[3]
2. R&D funding as a percent of the total Federal budget has declined by more than 75 percent in the last 54 years, 11.7% in 1965 to 2.9% in 2017.[4]
3. While venture capital is recently increasing in the US, most of the money is going into a few gigantic deals, and the number of venture capital seed deals continues to plummet. In 2Q 2018, 792 seed deals were closed, down 22% from 2Q 2017 (1022 deals). This is all part of the downward trend for smaller companies and startups. This follows declines for number of VC seed deals 2Q in 2017 and 2016 of 11% and 23% respectively. Software dominates VC investment with 42% of the deals, leaving little for other industries and for US strategic priorities. VCs invest half (49%) their money in 4 metro areas: San Francisco Bay, New York, Boston, and Los Angeles, leaving most of the other 362 metro areas without.[5]

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[2] Swearingen, Will, and Peterson, Jeffrey, *National Economic Impacts from the Air Force and Navy SBIR/STTR Programs, 2000-2013* (Techlink, 2018)

[3] Horizon 2020 in full swing, three years on, Key Facts and Figure 2014-2016, https://ec.europa.eu/programmes/horizon2020/sites/horizon2020/files/h2020_threeyearson_a4_horizontal_2018_web.pdf

[4] American Association for the Advancement of Science, https://www.aaas.org/page/historical-trends-federal-rd

[5] PitchBook, National Venture Capital Association, Venture Monitor, 2Q 2018, https://nvca.org/research/venture-monitor/

4. SBIR, the most successful innovation program in US, has been copied by 10 other countries including Germany, England and China, allowing them to catch up to the US. [6]
5. The US Government spends 70% of its R&D in areas that have no funds for transition to the marketplace. Civilian federal R&D spends no money on transitioning the R&D to the marketplace. Most Federal Research is never transitioned to into commerce, it usually does not get out of the Laboratory or university.
6. When university research is published it often results in commercialization and jobs being created overseas.
7. According to one report by Bloomberg News, the US has fallen to 11th in a world Innovation Index.[7] Another report by the US Chamber of Commerce has the US falling to #12 in patent rights.[8] The World Intellectual Property Association, an agency of the United Nations, reports that the US has fallen from number 4 in 2017 to number 6 in 2018 in the world in Innovation, and the Chinese have risen from #22 to #17.[9]
8.

SBTC answers to NIST RFI questions

(1) What are the core Federal technology transfer principles and practices that should be protected, and those which should be adapted or changed?

SBTC Response: Small business is the engine that drives American innovation.
Federal rules that impact on small business technology commercialization should be streamlined to remove barriers to effective transition to commercial application, with new supports put in place to encourage more effective transfer. Small business innovation must be protected for federal technology transfer to play a role in the innovation ecosystem.

1. Small businesses are a critical driver for innovation in the economy.
2. 70% of all university technology licenses go to small business.[10]
3. Small Business is far better at getting R&D funding to the marketplace than Universities and Federal Labs. Less than 1% of university licenses have revenue

[6] Wessner CW, ed, *An Assessment of the SBIR Program,* (National Academies Press, 2008)
[7] The U.S. Drops Out of the Top 10 in Innovation Ranking, Michelle Jamrisko and Wei Lu January 23, 2018, https://www.bloomberg.com/news/articles/2018-01-22/south-korea-tops-global-innovation-ranking-again-as-u-s-falls.
[8] *Create*, US Chamber International IP Index, Sixth Edition, February 2018, Figure XI: Scores, Category 1: Patents, Related Rights, and Limitations. https://www.uschamber.com/report/us-chamber-international-ip-index
[9] World Intellectual Property Organization, *Global Innovation Index 2018*, http://www.wipo.int/pressroom/en/articles/2018/article_0005.html#rankings.
[10] American University of Technology Managers, *FY2016 AUTM US Licensing Activity Survey*, (AUTM, 2018)

greater than one million dollars. Despite legislation and strong efforts, Laboratories still do not commercialize as well as small business.

4. 60% of SBIR Phase IIs create jobs and have sales in excess of one million dollars (versus the 1% of university licenses).[11]
5. 20% of all key innovations come from the SBIR Program.[12]
6. Economic impact of SBIR is $17 to every dollar spent.[13]
7. SBIR returns over $2.00 in tax revenue for every dollar spent. [14]
8. No other federal research program has been as successful at transitioning technology to the marketplace and creating jobs.

Despite the importance of small business, the Agencies and most of the policies of the Federal Government do not invest in what gives the Government the highest return on investment, small business. See our answer to Question #3 for SBTC's recommendations for improving federal technology transfer.

(2) What are the issues that pose systemic challenges to the effective transfer of technology, knowledge, and capabilities resulting from Federal R&D? Please consider those identified in the RFI as well as others that may have inhibited collaborations with Federal laboratories, access to other federally funded R&D, or commercialization of technologies resulting from Federal R&D.

SBTC Response: There remains a strong bias in the agencies against funding small business. Awarding many small contracts is viewed as a burden on overworked contracting officers. SBIR is frequently seen as a tax on other university or big company research. Funding for small business, as a percent of the budget or as a percent of R&D, has historically been low (compared to other countries, e.g.: 1/4 of the percentage of their budget that European countries spend). Cost sharing and other regulatory burdens dissuade small businesses from conducting Federal R&D and commercializing Federally-funded research, stifling innovation. Federal regulations and contracting guidelines have not been updated this decade. Laws promoting small business contracting have not been promulgated as regulations and program and contracting officers have not been trained in the current law (e.g: 2012 NDAA, passed in December of 2011). Every new rule or regulation should evaluate the impact on small business. Small business lending must be encouraged. Dodd Frank has made it more difficult for community banks to loan to smaller firms. Finally, the patent laws and regulations are strangling small businesses, clouding title to patents, and making it almost impossible for small businesses to enforce their patents. This institutionalization of retarding small business monetization of patents further cuts funding for small business commercialization.

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[11] Swearingen, Will, and Peterson, Jeffrey, *National Economic Impacts from the Air Force and Navy SBIR/STTR Programs, 2000-2013* (Techlink, 2018)

[12] Block, Fred and Keller, Matthew, *Where do Innovations Come From? Transformations in the U.S. National Innovation System, 1970-2006,* (ITIF, 2008)

[13] Swearingen, Will, and Peterson, Jeffrey, *National Economic Impacts from the Air Force and Navy SBIR/STTR Programs, 2000-2013* (Techlink, 2018)

[14] Swearingen, Will, and Peterson, Jeffrey, *National Economic Impacts from the Air Force and Navy SBIR/STTR Programs, 2000-2013* (Techlink, 2018)

(3) What is the proposed solution for each issue that poses a systemic challenge to the effective transfer of technology, knowledge, and capabilities resulting from Federal R&D? Please consider the approaches identified in the RFI.

SBTC Response:

1. **Double the amount of Federal funding going to small business.** This can be done by the agencies simply promulgating their own rules and regulations. NIST should encourage an Executive Order or new legislation that will require this by law.
2. **Create new programs for small business R&D. The innovation engine needs more fuel.** Again, his can be done by the agencies simply promulgating their own rules and regulations. NIST should consider leading these programs by working with the Executive Office of the President, Office of Science and Technology, to prepare an Executive Order for the President's signature. NIST should also encourage new legislation that will require more small business funding by law.
3. **Double the SBIR program allocation. Already recommended by DOD 809 committee.**[15] Agencies are free to allocate more funding to SBIR as only a minimum amount is set by statute. Once again, NIST should encourage new Executive Orders and legislation that will require this by law.
4. **Double the DOD's RIF program. DOD 809 recommendation.** Agencies are free to allocate more funding to the RIF program. NIST should encourage new legislation that will require this by law or assist its implementation by Executive Order.
5. **Create goals for agencies to award a minimum of 12% of their R&D to small businesses. (Still only 60% of what Europe invests in small business R&D.)** Agencies should be encouraged to set goals for small business R&D funding. An Executive Order or legislation will assist this process.
6. **Eliminate cost sharing for small business and universities in Federal R&D Programs.** Some civilian agencies require small business to cost share. This is usually not possible for most small businesses working to commercialize innovative technologies, screening against innovation and dampening the tech transfer and commercialization effort. It should be eliminated by the Agencies, the President, or Congress.
7. **Provide follow on funding for civilian small business research through programs like RIF.** Additional funding for the testing and evaluation of new R&D products and services should be encouraged by the Agencies, the President, or Congress.
8. **Update the FAR and DFAR to reflect legislative changes.** The FAR, DFAR, and other procurement manuals, documents, and training programs have not been updated this decade, severely slowing the impact of legislative improvements. This is

[15] Section 809 Panel, *Report of the Advisory Panel on Streamlining and Codifying Acquisition Regulations* (Department of Defense, 2018)

harmful to the economy and tech transfer efforts. This should be demanded of the Agencies to immediately implement laws passed by Congress. Further, reporting on small business issues required by Congress must be submitted.

9. **Streamline and simplify contracting and reduce the regulatory burden on innovative small business doing business with the Government.** Other Transaction Authority (OTA) is helpful in bypassing many burdensome regulations on small business. Insisting 5 person companies implement regulations written for multi-billion dollar corporations is not only impractical, but counterproductive to the essence of new technology introduction and the tech transfer effort. Accounting regulations are particularly time consuming, taking away from conducting research and transferring the technology into the economy for smaller contracts.
10. **Banking laws and regulations have made it more difficult for small businesses to obtain funding, thus retarding commercialization.** This is beyond the scope of NIST's and the Department of Commerce's mission, but it is important that tech transfer personnel be aware of deleterious effects the lack of capital has on the mission of tech transfer. The Department of Commerce should work with the EOP to encourage Congress to pass additional laws that facilitate the flow of capital to small businesses.
11. **Revise the patent laws to protect inventions and allow small businesses to enforce their patents and enjoin infringers.** This is one of the most critical items that must be accomplished by the Department of Commerce. It has a number of components.
    a. The Department should implement the USPTO's proposed new rules on claim construction (PTAB Notice of Proposed Rulemaking 2018 Docket number: PTO-P-2018-0036) as soon as feasible. This is important to help ameliorate the deleterious effects of the current rules of the patent office issued by the former administration under the *America Invents Act*. (See Attachment E, SBTC comments.)
    b. The USPTO should evaluate other rules for the PTAB to help clear title to patents as soon as possible. This will allow enforcement
    c. The Department of Commerce, working with the EOP, should encourage Congress to pass currently pending bills such as the Restoring America's Leadership in Innovation Act of 2018 (RALIA) (H.R. 6264) (see Attachment F, SBTC Letter of Support), STRONGER Patents Act (H.R. 5340), The Inventor Protection Act (H.R. 6657), and the TROL Act (H.R. 6370). Working to mitigate or better to totally reverse the very deleterious effects of the America Invents Act and its resulting cloud on patent titles caused by the PTAB will be one of the most important actions to help speed tech transfer and commercialization. Restoring injunctive relief by Congressionally reversing the SCOTUS *eBay* decision, and allowing many new patents be issued by Congressionally reversing the SCOTUS *Alice* decision will also encourage licensing (rather than efficient infringement) and deter the Chinese from absconding with US technology.
    d. Finally, the USPTO should hold seminars for Supreme Court Justices and for their clerks to inform them of the importance of patents in the economy. SCOTUS has

shown for a decade that they do not understand the importance of intellectual property on the innovation ecosystem and the cost that weak patents have on the economy. The USPTO can help provide that understanding.

(4) What are other ways to significantly improve the transfer of technology, knowledge, and capabilities resulting from Federal R&D to benefit U.S. innovation and the economy? What changes would these proposed improvements require to Federal technology transfer practices, policies, regulations, and legislation?

SBTC Response: Please see our comments above.

America's individual inventors and small businesses that have built this country, and have led its innovations. The key problem with Federal technology transition strategy is that it does not harness the entrepreneurial energies and ingenuity of American small business. Whatever is new is always vulnerable to the existing order, and Federal policy contains myriad defenses of the existing and too few encouragements and streamlining for the new. As you are looking for how to improve Federal technology transfer, look for ways to make it easier for small businesses to continue to make America great.

America needs a Small Business R&D Policy to encourage innovation. It should include the above recommendations.

Thank you for this opportunity to comment. Please feel free to contact us at alec@sbtc.org to obtain clarification or if you have additional questions. We would be happy to help provide additional input and would be delighted to participate in panel discussions or working groups on the subject.

Sincerely,
Small Business Technology Council

Jere W. Glover	Robert N. Schmidt	Kevin Burns
Executive Director	Co-Chairman	Co-Chairman

List of attachments:

A) SBTC 2017 SBIR Economic Impact White Paper
B) Air Force SBIR/STTR Economic Impact Study
C) Navy SBIR/STTR Economic Impact Study
D) SBIR/STTR: The Best Return on Taxpayer Dollar
E) SBTC Comment on USPTO Rulemaking Change
F) SBTC Letter of Support for RALIA bill

The Small Business Technology Council
1156 15th St NW
Suite 502
Washington, DC 20005

Small Business Innovation Research (SBIR): Leveraging American Business Growth and Jobs

SBIR: Entrepreneur-Driven R&D to Support American Economic Revitalization

A White Paper

January 19, 2017

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Executive Summary:
SBIR Offers a Lever for Economic Revitalization

Congress and President Reagan created the Small Business Innovation Research (SBIR) program in 1982 to mobilize small business entrepreneurship and innovation to bridge a technology gap eroding American competitiveness and jobs. SBIR solely funds R&D meeting agency objectives, but the follow-on economics are dramatic: SBIR leverages America's entrepreneurs and small business technical skill to innovate solutions to important American challenges while creating new products and jobs transforming American industry. Today, facing uneven economic growth and aging infrastructure, we can strengthen SBIR/STTR1 investment, unleashing small business energy and jobs in a new wave of 21st century American-made products and services.

Despite <1.7% of overall Federal R&D funding, SBIR/STTR is a primary driver of American economic strength. SBIR R&D projects are our technology seed corn. High quality R&D met Federal needs while seeding new startups and driving the growth of small businesses with their new technology products and services. Global giants such as Qualcomm, Symantic, Biogen, iRobot, Genzyme, Illumina, and Genentech emerged from SBIR funding. Meanwhile, SBIR businesses and technologies were also sold or licensed, energizing older industries while cutting costs and generating entire new divisions and new jobs located here in America. Follow-on new product investment and sales have totaled hundreds of billions of dollars.

SBIR firms produced life-changing breakthroughs in defense, energy, communications, information and bioscience - new tech building blocks for American manufacturing. Agency mission objectives were accomplished. DOD strengthened capabilities while cutting costs. The Air Force saved over $500M on the F-35 aircraft. A Navy project saved over $1M per hull on the Virginia Class submarine. University/small business collaborations converted basic science into products and services, with 30-60% of SBIR technologies involving current or former faculty. With less than 1.7% percent of Federal R&D, SBIR/STTR firms have created over 20 percent of America's major innovations, and as many patents as all universities combined.

America's basic science is a primary national strength, but converting that science to American innovations and jobs faces increasing international competition. **The SBIR/STTR program funds the seed corn for this challenge, combining private enterprise with American ingenuity to enable new innovations while building new products and businesses**. SBIR asks our nation's small businesses, employing 38% of our scientists and engineers and led by American entrepreneurs, to convert American science into new scientific breakthroughs and useful innovations for commercial use, and to use that tech to build their businesses. SBIR firms must be American-based and owned small businesses, with all work done in the U.S. The new technology, products and services advance agency missions, meet market and societal needs, and create new sustainable high quality, high paying manufacturing and service jobs while raising living standards.

The data supports this impact, and suggests doing more can increase the success. 17 National Academy of Sciences studies concluded SBIR met its goals and showed SBIR/STTR Phase II awards commercializing at rates from 45-70 percent, a remarkably high result. Recent economic impact studies

[1] Congress passed and George H. W. Bush signed Public Law No: 102-564, which created a smaller, companion Small Business Technology Transfer (STTR) program in 1992, for academic partnering.

by the Air Force and Navy SBIR/STTR programs detail job and wealth creation with broad regional benefits, plus provide data on taxes and revenue paybacks. The SBIR/STTR program clearly provides a big bang for the federal R&D dollar.

- Both Air Force and Navy found high SBIR returns, e.g. the Navy found every dollar invested in the Navy SBIR/STTR programs led to over $6 of new product sales and over $19 of total American economic output just within a 14 year period. Tax income in the period more than repaid the SBIR R&D funding. Job quality was high, with average income of $68,535.
- The studies did not capture the large sales and economic effects from technologies sold or licensed. Over 13% of the Air Force small businesses had been acquired for their SBIR technology by larger firms and an additional 10% of the technologies were licensed to other firms, energizing the defense contractors that acquired or licensed the technologies and creating the base for new business divisions.
- Federal tax calculations show the SBIR/STTR program more than repays the government investment: $1.46 in increased Federal taxes for every dollar spent on SBIR. State and local taxes add another 71¢, for a total return of 217%, just in taxes.

SBIR/STTR outreach to underserved states and groups is broadening the impact and strengthening national STEM results. SBIR/STTR is leveraging the nation's dramatic spread of "innovation hubs" in geographically disenfranchised regions, led by regional industry/academic/ government partnerships, and redefining STEM. New products meeting important American STEM challenges are energizing new generations looking for meaning in work. Increased heartland investment in SBIR/STTR, with technology mining by large firms committed to public infrastructure revitalization, can become a keystone of the Rustbelt's manufacturing revival.

Long-deferred American public infrastructure revitalization offers the same opportunity for improved performance via SBIR/STTR innovation and new STEM architectures that has transformed the defense, energy, bioscience, communication, and information industries. SBIR/STTR infusion offers the potential for simultaneous performance improvements and dramatic cost reductions throughout our economy as we reinvigorate our infrastructure.

As we consider how to sustainably grow America's economy with new products and jobs capable of fully engaging and employing America's workforce with high quality jobs, **SBIR/STTR offers a highly-efficient proven innovation lever for American economic revitalization that creates new technology and jobs within existing R&D budgets.** With 35 years of Congressional support for small business innovation as an unmatched economic growth engine, small firms already generate over 20% percent of America's top technologies and ~40% of tech employment.

We should build on programs that work in creating economic strength, and make them stronger. The new Administration and the 115th Congress have an opportunity to improve the impact of American skill and entrepreneurship building on America's scientific strength, with the SBIR/STTR program as the fulcrum for creating new innovations and better jobs.

Recommendations:

1. Grow the SBIR/STTR allocation to create more new technology, businesses and jobs.
2. Continue to grow America's long term investment in R&D to support our high value economy.
3. Ensure agencies follow SBIR/STTR policies, including for Phase III support.
4. Reduce paperwork/administrative burden relating to proposals, contract admins and accounting.
5. Focus DOD's Rapid Innovation Fund to SBIR. Develop similar programs at other agencies.
6. Maintain strong intellectual property protections for these new technologies and businesses.

DISCUSSION

1. SBIR/STTR: Innovation-focused R&D for New Products, Services and High-Quality Jobs

With repeated favorable, detailed assessments by the National Research Council, Government Accountability Office, and Office of Management and Budget since the 1990's, the SBIR/STTR Program has emerged as a very productive component of Federal R&D, delivering high-quality science and engineering solutions for American use. SBIR/STTR innovations convert basic science into products and services to transform the American economy, and create new high-quality jobs.

Through early SBIR/STTR work and its commercialization focus, thousands of firms have started and prospered while not a few garage R&D startups (Qualcomm, iRobot, etc.) have become global tech giants. Many other SBIR technologies have been licensed or sold to other American businesses, re-energizing older industries while cutting costs and generating countless new 21st century jobs.

Planned by Congress to ensure American R&D competitiveness, the program has a simple three-phase structure (Figure 1), with competition as its keystone: just one in eight Phase I proposals is awarded, and only one in 20 go on to Phase II. Annually, about 30 percent of awardees are new to SBIR/STTR.

Figure 1 – Source: Dept. of the Navy SBIR/STTR Program

Phases I and II are funded within large agency R&D budgets, targeted to meeting agency mission objectives, in a disciplined, highly competitive structure. Phase III describes follow-on activity outside of SBIR funding, wherein the newly created innovations enter the economy either through commercial sales or follow-on R&D. The Phase I/II SBIR R&D dollars are leveraged by the follow-on R&D and sales, as well internal investment and energy from the small business. Around 14 percent of all SBIR firms have eventually received venture capital and one of every eight dollars invested by VCs is to an SBIR/STTR involved firm. Many large companies have acquired smaller growing firms driven by SBIR technology, for both the products and the technology, transforming themselves with the infusion of the new technology.

Now, a new wave of SBIR/STTR studies[2] is documenting profound economic impact measured by job creation, high wages, tax revenues, and innovation networks throughout regional economies with resident SBIR/STTR entrepreneurs. From 2000-2013, for example, the Naval SBIR/STTR Program invested $2.3B in Phase II awards estimated to create $44B in economic activity over the period while generating $3.35B in federal taxes – effectively paying for the investment, not counting the longer term effect on jobs and quality of life. As America struggles to level the playing field of economic inequality, SBIR/STTR provides promise and direction, innovating new solutions and combining these with entrepreneurial energy to build new businesses and jobs to replace those lost to industrial obsolescence and foreign competition.

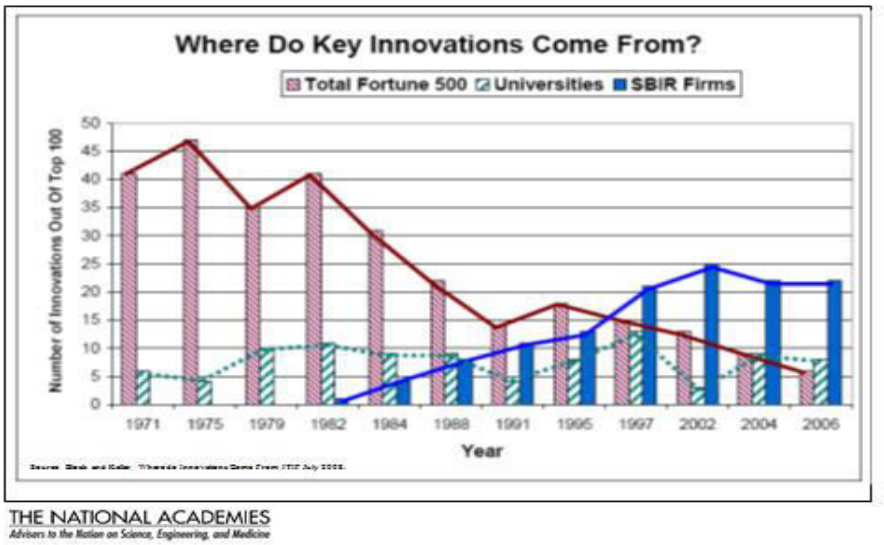
From this Navy study, we see that every dollar invested in SBIR creates $1.46 in Federal taxes, a 46% return. Thus, we have a program which creates tax dollars, not spends them. Further, the SBIR program generates another 71 cents in state and local taxes for every dollar invested in SBIR.

1.1 Program Objective Achievements

Congress learned in a January, 2016 hearing on SBIR[3] that when Arthur Obermayer, one of the founders of the SBIR program, was inducted into SBIR Hall of Fame at the White House, he stated that next to the GI Bill after WWII, SBIR was one of the most significant pieces of legislation ever passed by Congress. Information provided to the Senate Small Business Committee included two vital facts:

a. The SBIR/STTR Program has been copied by 17 nations around the world.
b. With less than 1.7 percent of the Federal R&D budget, SBIR/STTR has created 22 percent of America's key innovations (Figure 2).

Figure 2 – SBIR Role in American Innovation



Source: Fred Block and Matthew R. Keller, "Where Do Innovations Come From? Transformations in the U.S. National Innovation System, 1970-2006", THE INFORMATION TECHNOLOGY & INNOVATION FOUNDATION, July 2008, pg. 15

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2 TechLink center at Montana State University-Bozeman, in collaboration with the Bureau Research Division of the University of Colorado-Boulder, completed studies of the Air Force SBIR/STTR Program (2015) and the Naval SBIR/STTR Program (2016). TechLink engaged with the Dept. of Defense Office of Small Business Programs in 2016 to study economic impact of other DOD entities.

3 Jere Glover Testimony " Reauthorization of the SBIR/STTR Programs – The Importance of Small Business Innovation to National and Economic Security " before the Committee on Small Business and Entrepreneurship, U.S. Senate; January 28, 2016, http://www.sbc.senate.gov/public/?a=Files.Serve&File_id=57625744-A72A-424D-8B0B-90E3385108EF.

Committee members also learned that the National Academy of Sciences and its National Research Council's (NRC) 17 reports on SBIR/STTR found that the program meets principal Congressional objectives for SBIR/STTR: (1) to stimulate technological innovation, (2) use small businesses to meet federal R&D needs, and (3) increase the private sector commercialization of innovations derived from federal R&D.

SBIR Over-Achievers: From the Garage to the Globe

Recognizing that Congress seeks tangible evidence of SBIR success, Jere Glover, Executive Director of the Small Business Technology Council, part of the National Small Business Association, produced a signature sample of firms, "… making this the most successful innovation commercialization program in America. Successful alumni of the SBIR program are firms like: **Qualcomm** (cell phone communications), **Symantec** (computer security), **Genzyme** (biotech therapies), **Affymatix** (GeneChip), **Amgen** (biopharmaceuticals), **Jarvick Heart** (artificial heart), **Titan Corp** (information and communications), **Chiron** (pediatric vaccines), **ATMI** (semi-conductor materials and environmental system) (**AMTI** (advanced materials, radars), **Amorworks** (military armor), **Biogen** (Idec, neurological, autoimmune therapies), **American Biophysics** (mosquito control), **Millennium Pharma** (gene databases), **Geron** (telomerase inhibitors for cancer treatment), **Neocrine Bioscience** (neurological and endocrine pharmaceuticals), **ABIOMED** (world's smallest heart pump), **Aerovironment** (unmanned aircraft), **A123 Systems** (lithium-ion batteries), **FuelCell Energy** (fuel cells), **iRobot** (unmanned robotic vehicles and domestic robots), **JDS Uniphase** (fiber optics, lasers, software), **Stem Cells Inc**. (cell based therapies for CNS and liver disorders), **Intra Lasek** (optical surgery), **Illumina** (genomics) and **Nanosys** (quantum dot displays)."

With global graduates in a pool of more than 700 publicly-traded big firms, the SBIR/STTR program is a formidable jobs engine – especially as firms leave SBIR/STTR incubation, or join 1,975 others in being acquired by larger firms, according to the Innovation Development Institute of Swampscott, MA.

National Academy of Sciences: Repeated Stamps of SBIR Approval

While the Government Accountability Office and Office of the Inspector General have scrutinized and reported on SBIR/STTR Program mechanics more than 25 times since 2000, NRC made a definitive SBIR assessment in a series of reports from 2004 to 2009, comprising thousands of pages, on the SBIR programs at the Department of Defense (DoD), National Institutes of Health (NIH), National Aeronautics and Space Administration (NASA), Department of Energy (DoE), and National Science Foundation (NSF)—the five agencies responsible for 96 percent of SBIR operations.

"**The core finding of the study**," NRC wrote, "**is that the SBIR program is sound in concept and effective in practice."**[4] NRC grouped SBIR program results across federal agencies into four categories, with 380 pages of supporting data:

- Stimulating Technological Innovation
- Increasing Private Sector Commercialization of Innovations
- Using Small Business to Meet Federal Research and Development Needs
- Fostering Participation by Minority and Disadvantaged Persons in Technological Innovation

[4] *An Assessment of the SBIR Program;* National Research Council; April, 2008; pp. 3-7

In repeated appearances before Congressional committees of the House and Senate discussing SBIR reauthorization between 2004 - 2011, NRC science and technology studies director Dr. Charles Wessner advocated strongly for SBIR/STTR expansion and administrative strengthening, especially to enable more outreach to economically disadvantaged areas such as America's Rust Belt, and to women entrepreneurs.

National Academy of Sciences: STTR Partners with SBIR to Advance American R&D

NRC complemented its SBIR assessment sequence in 2016 with *STTR: An Assessment of the Small Business Technology Transfer Program.* "STTR is meeting its congressional objective of fostering cooperation between small business concerns and research institutions, and does so in some respects to an extent that SBIR does not," NRC wrote[5] in this data-driven study. Noting significant agency application differences between STTR programs, NRC found that "To a considerable extent, STTR fosters private sector commercialization of innovations derived from federal R&D." What NRC explored, in SBIR or STTR assessments, is **technology commercialization, finding rates of between 45 to 70 percent** depending on the agency, and direct university collaboration between 33 and 63 percent of SBIR awards.

1.2 Different Agency Missions, Different Agency Outcomes

Because the SBIR/STTR statute defines the programs as Federal extramural R&D, expressed at the agency level[6] in their annual budgets, ownership of SBIR and STTR budgets – and program management, therefore – is vested in the assessed agencies. Consequently, each agency's SBIR/STTR program takes formal notice of that agency's mission, giving the SBIR/STTR program across 11 agencies a remarkably diverse character. SBIR/STTR is tailored by each agency, with results tracked and reported. The diversity also leads to opportunities for comparative evaluations towards continually improving best practices.

Missions and SBIR/STTR Topics: Diverse by Definition

Consider, for example, the formal missions of two agencies with prominent SBIR/STTR programs:

- "The mission of the **Navy** is to maintain, train and equip combat-ready naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas."[7]
- "To promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense; and for other purposes. **National Science Foundation** (NSF) envisions a nation that capitalizes on new concepts in science and engineering and provides global leadership in advancing research and education."[8]

SBIR/STTR topics reflect these different missions. Agencies that don't procure advanced technologies may publish SBIR/STTR topics written generally to accord with their basic R&D interests on the leading edge of innovation – such as NSF or the National Institutes of Health within the Dept. of Health & Human Services. On the other hand, Dept. of Defense (DOD) agencies seek high quality R&D solutions for defense challenges, and issue precisely written topics with potential follow-on purchases of products and services designed to ensure that American warfighters are equipped for success in emerging battlefields.

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5 *An Assessment of the Small Business Technology Transfer Program;* National Research Council; June, 2016; pp. 4-6

6 By statute, and the accompanying *SBIR/STTR Policy Directive* published by the Small Business Administration, the SBIR assessment is taken for each Federal agency with an extramural R&D budget above $100M. The STTR assessment is taken for each Federal agency with an extramural R&D budget above $1B. The *Directive* provides detailed instruction on tracking and reporting.

7 https://www.navy.com/about/mission.html

8 https://www.nsf.gov/pubs/2014/nsf14002/pdf/02_mission_vision.pdf

Agencies such as the Dept. of Energy, which doesn't procure innovation but is focused on American energy needs, publish topics designed to guide innovation and extend promising applied research from DoE's national laboratories such as Los Alamos NM and Oak Ridge TN. NRC, in its SBIR and STTR assessments, has regarded such diversity as the program's backbone, and insurance that SBIR/STTR makes a broad, deep and practical contribution to American R&D. NRC studies have chronicled substantial SBIR/STTR commercialization at non-procuring agencies, evidence of the commercial vitality of SBIR/STTR technology solutions.

Missions and SBIR/STTR Commercialization Assistance: Diverse by Design, and Statute

Similarly, agencies have tailored assistance to SBIR/STTR awardees since 1999 in strengthening their small businesses to accord with entrepreneurial needs to achieve commercialization. Congress first mandated this in 2002 SBIR/STTR reauthorization by emphasizing the importance of project commercialization plans in evaluating SBIR/STTR proposals. But Congress went on to expand the commercialization focus significantly in 2011, authorizing agency pilot plans to accelerate SBIR/STTR commercialization for agencies other than the Dept. of Defense. Now all SBIR/STTR awardees have the option of using some award funds to hire technology commercialization experts.

Agencies that procure advanced technologies, led by DoD military departments, offer commercialization assistance that facilitates small business transition to DoD, including production capability and requisite certifications. Such DOD practices resonate with increasing warfighter and acquisition command acceptance of SBIR/STTR. Best practice examples include two Naval documents, *Tapping Into Small Business In a Big Way* – guidance issued in January 2015 by the Assistant Secretary of the Navy for Research, Development and Acquisition – and the *Dept. of the Navy SBIR/STTR Phase III Guidebook for Program Managers and Contracting Officers,* a 2014 Naval desk reference in standard use throughout Naval Systems Commands, and elsewhere in DoD organizations.[9]

Agencies that don't procure also select SBIR awards based upon anticipated benefit and commercialization potential. As these agencies achieve their missions when SBIR technologies reach the commercial marketplace, they also offer assistance to help small business identification of potential markets and customers and can further support successful SBIR projects through their regular agency R&D awards. The SBIR program currently only uses a very small fraction of agency external R&D – the remainder (some 97%) is spent with large businesses, national labs and universities on R&D. Yet some 38% of the nation's scientists and engineers work in small business, with high skill given the high levels of success. The non-procuring agencies could decide to further their mission achievement by opening up their regular R&D awards to the highest performing of their SBIR projects, the ones determined most promising to best support the agencies' missions. These agencies are also required by the 2011 reauthorization to make Phase III awards to the SBIR innovators "to the greatest extent practicable" to accelerate commercialization of SBIR/STTR technologies for domestic markets. Some agencies and departments have been slow to implement the provisions of the law.

While assessments of SBIR/STTR technical assistance curricula has varied, the consensus is that about 70% of all DoD and NSF SBIR/STTR projects receive non-SBIR/STTR commercialization investment or sales revenues, as do about 49% of all SBIR/STTR projects funded by NIH, NASA and DoE.[10]

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[9] Both documents are found at http://navysbir.com.

[10] *An Assessment of the SBIR Program;* National Research Council; April, 2008; pp. 59-60

Amidst years of Congressional efforts to improve American R&D commercialization – including the Bayh-Dole Act among several pieces of legislation – SBIR/STTR has a continuous and steadily-improving record of successful technology commercialization.

1.3 Strengths and Improvement Areas

Principal strengths of SBIR/STTR are found in many areas:

- **Seed funding**: With per project funding of up to $3M available to its awardees across a wide swath of Federal agencies, SBIR/STTR is a unique **seed fund for American technological innovation**, investing at the earliest stages in technologies that are pre-commercial and prior to stages at which Venture Capital is interested. Awards are strictly merit-based in this highly competitive program with only 1 in 20 proposals reaching Phase II, and the program's success supports American economic revitalization.
- **Uniquely American approach to draw on the energy of technology entrepreneurs**: The SBIR program taps American entrepreneurs and the 38% of our scientists and engineers employed by small business to solve Federal agencies' most important long range technology challenges and opportunities, and to create new products and services in the small businesses that create most of America's new jobs.
- **Jobs driver**: With the current studies of agency SBIR economic impact, this program emerges as a very **significant jobs-and-wages engine** for regional economies nationwide, where the multiplier effects of the new products and services create ripples of growth as dollars turn over within that region.
- **American manufacturing on-ramp:** Congressional emphasis on delivering SBIR/STTR innovation to warfighters and domestic user alike, SBIR/STTR enables small business to experiment with prototype development from promising R&D, followed by scale-up to actual product manufacture. Further, SBIR/STTR has links to key Federal advanced manufacturing and additive manufacturing programs.
- **Intellectual property development**: Intellectual property is the bedrock for good American jobs, and the number one indicator of regional wealth. The SBIR program is focused on developing IP.
- **High impact R&D program**: With commercialization of innovative R&D as an SBIR/STTR objective, a high commercialization rate, and a history of growing tech firms with global clout, the program invests ~$2.5B annually in **practical R&D, creating new industries such as robotics, MEMS, additive manufacturing, and new medical devices**, in addition to revitalizing old industries. Although SBIR/STTR is less than 3.5 percent of Federal external R&D, it's proven capable of delivering useful innovation in the form of products and services. Further, such practical R&D is the work of an otherwise underutilized American asset: small business science/engineering skill.
- **Technology-driven cost-savings**: With economies in cost, prototype scale-up and production, SBIR/STTR can generate **critical cost savings** – as has been noted by the American defense sector[11]:
  - **F-35 Lightning II fighter plane**, according to Air Force Lt Gen Chris Bogdan, has realized more than $500M in cost savings to date through use of SBIR/STTR technology and manufacturing solutions – a bright spot in an otherwise gloomy fiscal picture.
  - The **MRAP vehicle** that saved lives in Iraq and Afghanistan, according to Army and Marine Corps sources, realized a 90% savings in live-fire testing through use of SBIR/STTR technology.
  - The ***Virginia*-class submarine**, according to Naval Sea Systems sources, realizes cost savings and avoidance of ~$1M per hull by using one SBIR project's technology in the boat's communications system alone, and millions more with SBIR/STTRs in additional submarine systems.
- **New startup formation and technical business help**: SBIR/STTR is a **virtual incubator for entrepreneurs** in remote rural areas, dense inner cities, and anywhere else economic revitalization is needed. SBIR/STTR administrative funding encourages such new entrepreneurship. **Innovation partnerships**:

[11] Cost saving/avoidance detail for DoD ACAT Programs is available from appropriate MILDEP SBIR/STTR Program Offices on request, and from the Secretary of Defense (OSD) Office of Small Business Programs.

With its links to government, university, laboratory and industry partners, SBIR/STTR is a unique **venue for collaborations of regional or national R&D stakeholders** – the seed corn for domestic economic vitality.

- **Competition:** With rigorous emphasis on innovation and competition at Phases I and II, SBIR/STTR levels the playing field between experienced R&D practitioners and fresh "garage-stage" entrepreneurs. Year in and year out, about 30 percent of SBIR/STTR awardees are first-time winners, NRC found.

Areas for SBIR/STTR improvement touch on six frequently discussed issues[12]:

- **American small business employs 38 percent of our scientists and engineers, but receives only five percent of the Federal 135 billion dollar R&D budget, with the SBIR/STTR programs comprising only 1.7%.** This misses the historically-demonstrated American potential for technology and jobs growth represented by our entrepreneurs and small businesses, and compares poorly competitively with the European Union's current 16.9 percent direct award of EU R&D work to small business. As basic science has grown more complex and innovation has increasingly required both high levels of technical skill and entrepreneurship, our continuing underutilization of America's small business engineers, innovators and job creators in Federal R&D misses a primary opportunity to strengthen our economy.
- **Updating and streamlining of the Federal Acquisition Regulation** is needed to simplify the SBIR process.
- **Small business R&D goals required in the law need to be implemented and enforced.**
- **Non-DoD domestic agencies, given Phase III authority and commercialization encouragement by 2011 SBIR/STTR authorization, should consider how to further development of their most successful SBIR/STTR projects.** While DOD has opened up its non-SBIR R&D programs for follow-on projects to successful SBIR Phase IIs funded with their large regular R&D budgets, the non-DoD agencies in general have not supported such follow-ons. The data suggests this may be short-sighted, especially as venture capital remains focused on more advanced technologies that have near term commercial potential. Naval and Air Force success with SBIR/STTR Phase IIIs, plus the success of the Rapid Innovation Fund and its high number of applicants, have demonstrated the effectiveness of available sources of Federal follow-on funding for advancing SBIR/STTR technologies.
- Statute authority for **DoD components to promote Phase III awards "to the greatest extent practicable"**[13] should be implemented through a combination of better education of acquisition personnel[14], better reporting of Phase III awards including capture of non-Federal investment, performance monitoring by the Government Accountability Office, and incentives to core acquisition personnel. Expediting of required sole source contracting of Phase III projects will save costs by both Government and small business contractors by eliminating time wasting inefficiencies.
- The Government-Industry Advisory Panel should work to **ensure data rights and patent protections for small business inventions**. This includes Panel work regarding rights in technical data, the validation of proprietary data restrictions, and the regulations implementing such sections. Protecting this intellectual property will help stop the bleeding of important American inventions and associated jobs to foreign nation competitors. Any requirements of Broad Agency Announcements (BAA) requiring relinquishment of these data and patent rights should be prohibited.

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12 *How Congress Can Help SBIR Companies Create Jobs;* Small Business Technology Council; June, 2014, http://sbtc.org/wp-content/uploads/2014/06/SBTC-White-Paper-June-25-How-Congress-Can-Help-SBIR-Companies-Create-Jobs-6-20-2014.pdf

13 Section 638, title 15, United States Code (15 U.S.C. § 638 [2012]),1 subsection r(4)

14 See, for example, *SBIR and STTR Phase III Guidebook for Program Managers, Contracting Officers and Small Business Professionals;* Naval SBIR/STTR Program Office; May 2016.

- **The shrinking of the Federal R&D base also causes the jobs-creating SBIR allocation to decrease proportionately**. Combined with the 2011 inflation catchup boost in the size of Phase I and II awards, this has led to a decrease in the number of awards. With a relatively steady over time 1 in 8 Phase I proposals selected for a proof-of-concept award, and only 1 in 20 advancing to Phase II, together with rapidly increasing proposal costs for meeting increasing proposal administrative requirements and arbitrary financial restrictions raising business costs, the number of proposals has also decreased proportionately with the awards. There appears to be substantial innovation capacity in the nation for many more high quality proposals if the SBIR budget could be increased and red tape could be cut.
- **American technological competitiveness is based upon entrepreneurship and R&D, and should be ensured through increased R&D and SBIR/STTR funding**. R&D funding as a percentage of GDP shows a decline of over 60% percent over the last four decades, as seen in **Figure 3**, below. Federal R&D spending has fallen about 70 percent as a percentage of the Federal budget in the last 50 years, as seen in **Figure 4**. Importantly, this decline may correlate with the troubling downtrend trend of participation by new companies in the nation's high-tech sector, seen in **Figure 5**. Because it's now a given that small business is the American jobs engine, this downtrend is of special concern. Investment in R&D is a critical priority we can have for high quality job and wealth creation as patents are the number one indicator of high wage jobs and regional wealth. [15]

In an age of increased global competition, including competition with increasingly capable allied nations as well as a world of developing nations offering lower wage costs, America cannot afford an R&D and innovation deficit among our best job creators. SBIR clearly provides more bang for the Federal R&D buck than any other innovation program.

[15] See Federal Reserve Bank of Cleveland, "Altered States: A Perspective on 75 Years of State Income Growth," *Annual Report 2005*. For more detail, see Paul Bauer, Mark Schweitzer, Scott Shane, *State Growth Empirics: The Long-Term Determinants of State Income Growth*, Working Paper 06-06, Federal Reserve Bank of Cleveland, May 2006, https://www.clevelandfed.org/en/Newsroom%20and%20Events/Publications/Working%20Papers/2006%20Working%20Papers.aspx and then Click on the PDF for WP-06-06 by Bauer *et. al*.
See also, Patenting Prosperity: Invention and Economic Performance in the United States and its Metropolitan Areas Jonathan Rothwell, José Lobo, Deborah Strumsky, and Mark Muro. Being in a high patent region adds $4,300 per worker to annual income, which is $8,600/year for a two worker household. http://www.brookings.edu/~/media/research/files/reports/2013/02/patenting-prosperity-rothwell/patenting-prosperity-rothwell.pdf page 15.

- **Figure 3 – Federal R&D Funding as a Percentage of Gross Domestic Product**

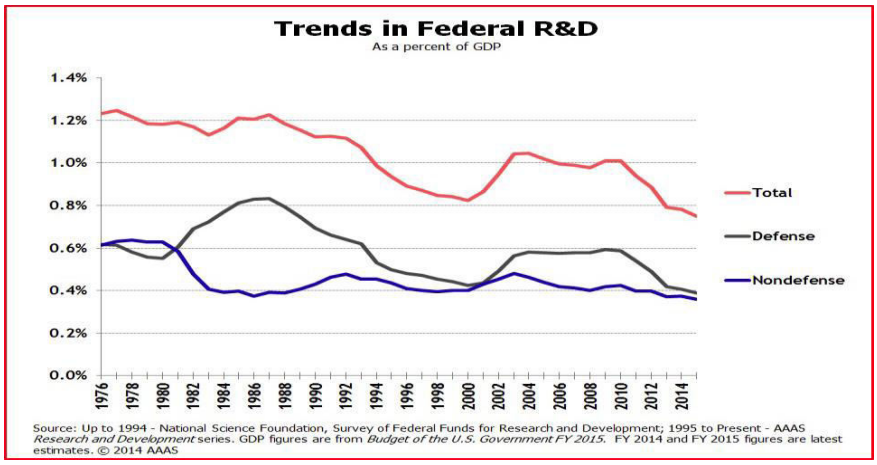


Figure 4 – Federal R&D Funding as a Percentage of the Federal Budget

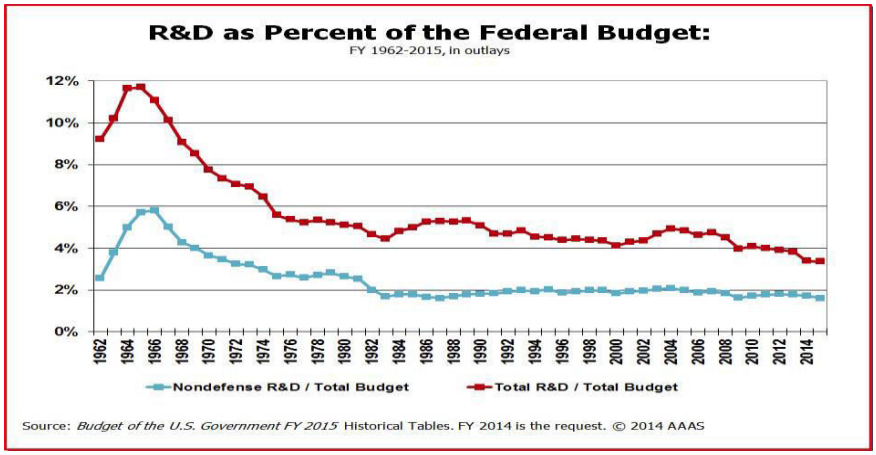
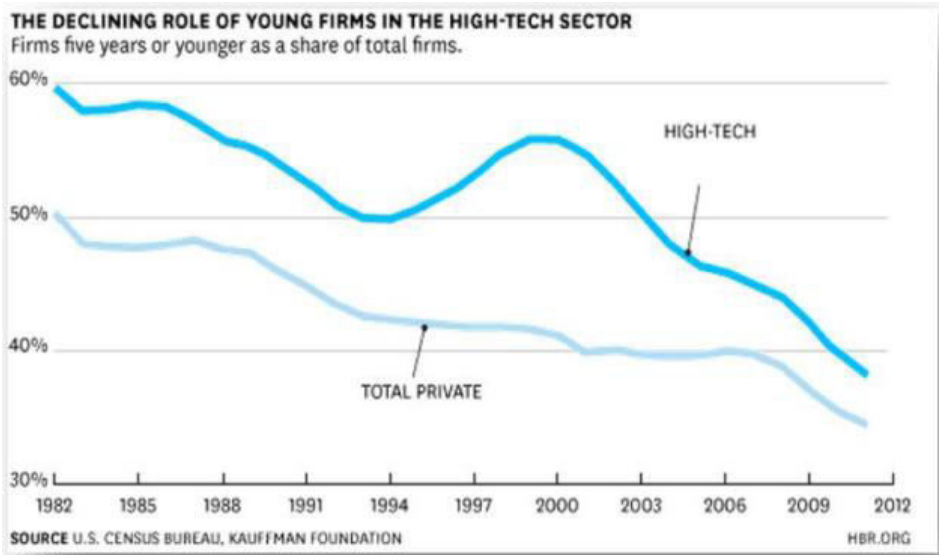


Figure 5 – Declining Role of New Technology Companies

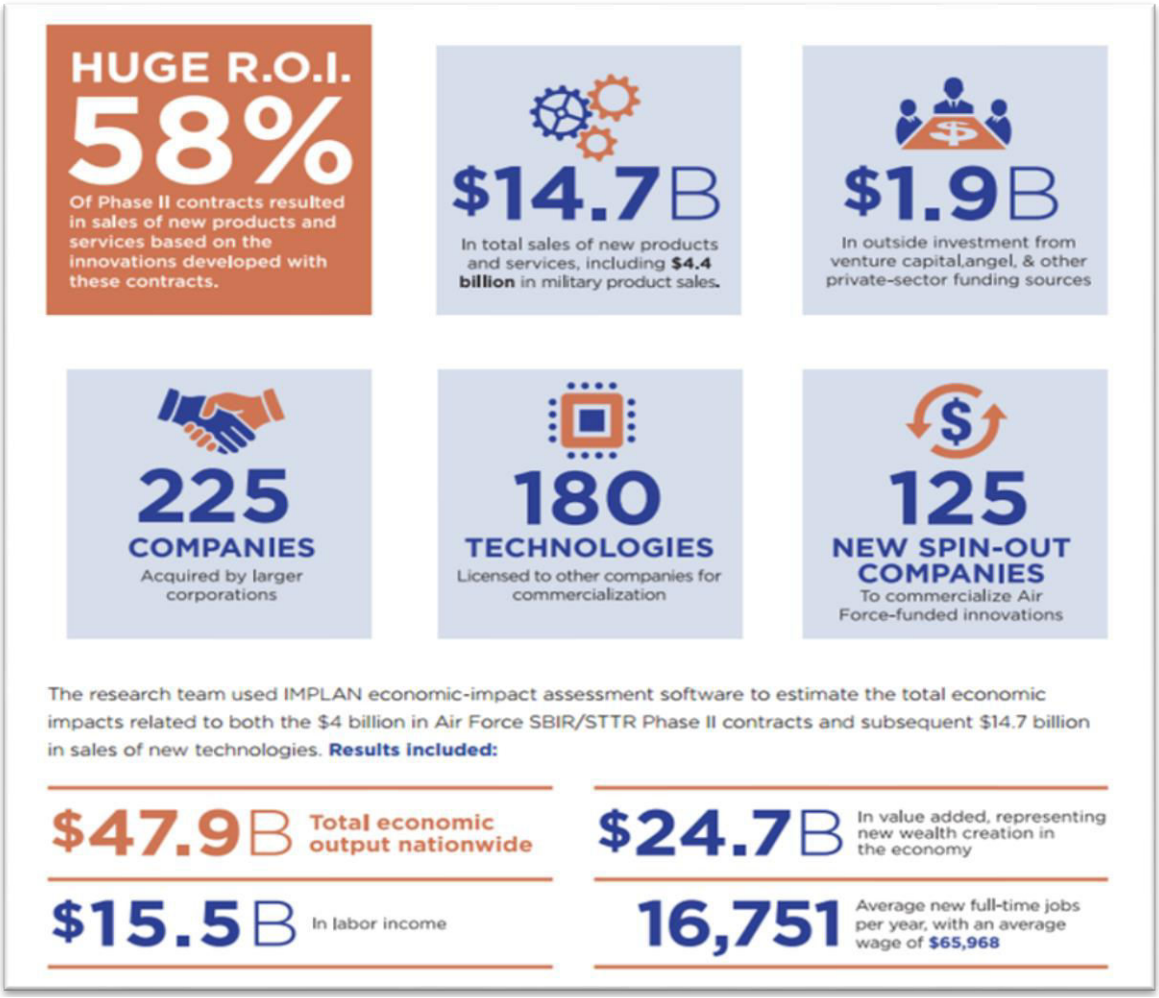


1.4 Economic Impact

SBIR/STTR programs of the Army, Navy/Marine Corps and Air Force began in the late 1990's to assess success and publish short "success stories" of SBIR/STTR technologies transitioning into DoD platforms and systems[16]. Typically, these have averaged one per month, and non-DoD agencies including the Small Business Administration have emulated such publication as a performance measure.

In 2014, however, the Air Force SBIR/STTR Program took the unprecedented step of commissioning an assessment of the economic impact of its Phase II investments over the period 2000 – 2013: a performance measure of significance for American economic revitalization. The extraordinary results, depicted below in **Figure 6**, an infographic from the study[17], immediately came to Congressional attention. (*Note:* the results below are understated in that they do not capture the sales and jobs effect that Air Force SBIR/STTR technologies had on licensees or acquirers of these technologies.)

Figure 6 – Air Force SBIR/STTR Economic Impact, 2000 – 2013



16 See, for example, http://www.navysbir.com, or http://www.afsbirsttr.com, or https://www.armysbir.army.mil

17 *The Air Force Impact to the Economy Via SBIR-STTR;* US Air Force SBIR/STTR Program Office; 2015, https://www.sbir.gov/sites/default/files/USAF%20SBIR-STTR%20Economic%20Impact%20Study%20FY2015.pdf

After publication of this revelatory study, the Dept. of the Navy SBIR/STTR Program engaged the same research firm to apply a refined data analytics model to its own record of Phase II investment for the same period, 2000 – 2013. While the Naval and Air Force SBIR/STTR Programs are not exactly comparable, the Navy results[18] (**Figure 7**) showed the same profound economic impact of job creation, high wages, and multiplier effects in regional economies – plus Federal tax revenue data showing that Naval SBIR/STTR Phase II investment of $2.3M returned $3.5M in taxes to the US Treasury – suggesting that SBIR/STTR Phase II investment paid for itself with a hefty cash return on the investment, in addition to the impacts of the technologies on performance and costs and the jobs/wages benefit. Also, by generating more than $0.71 in state and local taxes for every dollar invested by SBIR, it strengthens the local communities where SBIR investments are made.

Figure 7 – Naval SBIR/STTR Economic Impact, 2000 – 2013

18 *Small Business > Big Impact: Naval SBIR/STTR Investment 2000-2013;* Dept. of the Navy SBIR/STTR Program Office; 2016

Both the Air Force and Naval SBIR studies had a higher response rate (>90%) from queried small firms than did any of the NRC studies. Further, these two studies developed broader and more meaningful metrics in showing the value of SBIR commercialization and job creation.

With additional Federal agencies looking at SBIR/STTR's economic impact, President Trump and the 155th Congress can expect to see data arguing that the SBIR/STTR contribution to American R&D is more than great technology: it is jobs, high wages and strong regional impact to support economic revitalization.

2. SBIR/STTR: Dramatic, Lasting Impact on the American Economy

Technology drives opportunities for sustainable economic advantage and offers a path to preserve America's high value jobs and wealth. The 21st century economy is driven by technology, and jobs and fortunes will be made or lost based upon the flows of technology. The 2016 American elections highlighted America's economic tensions as we work to preserve our standard of living while much of the world seeks to raise its standards. To sustain America's strength we need to continue to invest in R&D and to innovate new technologies. SBIR/STTR provides a demonstrated capability to do fulfill the larger promise of American R&D, via national economic revitalization. The 115th Congress, as it takes up SBIR/STTR improvement and the larger issue of R&D revitalization, can be expected to view this landmark, high-achieving program through a new lens of opportunity for American defense/security, American energy, and American public infrastructure.

2.1 Driving Role of Technology in the Economy

The story of post-1945 global trade shows successive waves of nations rising to challenge older economies, partly through lower labor costs but mostly through integration of technologies that hiked productivity, lowered manufacturing costs, and accelerated product delivery.[19] While new science such as robotics eliminates older assembly jobs, new technology jobs at higher wages are created[20].

What SBIR/STTR has done already to buoy the defense, space, energy, IT and bioscience industries, it can do for other American industries such as infrastructure construction – with robust economic benefits.

2.2 From Basic Science to Innovation, Jobs and Products

Practical innovation – a good working definition of SBIR/STTR – is necessary to transform basic science into useful products and services. With his light bulb innovation, Thomas Edison took electrical current science to a life-changing level. SBIR/STTR topic problems, whether from the Dept. of Agriculture or the National Cancer Institute or other agencies, challenge entrepreneurs to apply science and engineering skills to development of innovative "form/fit/function" solutions. SBIR/STTR, through its seed funding, technological mentoring and commercialization assistance, provides the juice for such solutions.

These American-bred solutions, born of basic science through R&D, lead to substantial well-paying American jobs, and to the revenues that keep American regional economies spinning and growing. While the SBIR/STTR statute is silent on regional economic benefit, small businesses see themselves as local players linked to local economies to provide goods and services essential to business growth, and to universities or similar STEM talent sources to provide employees. An SBIR business's jobs also tend to stick to the regions where they were created.

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19 *Making America 1953 Again;* Washington Post; December 29, 2016

20 https://techcrunch.com/2016/05/13/robots-wont-just-take-jobs-theyll-create-them

SBIR fills a key gap in America's innovation economy, the often-long and risky path from fundamental science to products. America's universities are excellent at developing fundamental basic science and research, using some 35% of Federal external R&D. But converting basic science to innovations for new products and services and jobs is a bottleneck in the pipeline. VCs and major companies tend to not tackle early stage innovations, seeking product opportunities with most of the technology risk removed. This leaves an innovation gap, between basic science and marketable products.

Bank lending to small business remains severely depressed: since 2008 lending to small business has declined by $99B, with many big banks that received TARP recession recovery funding abandoning small business lending. Venture capital investment for seed funding, and investment beyond Silicon Valley, has decreased dramatically. Since 2008 venture capital has declined for first-round financing in particular, and for early stage investment generally. In 2015, venture capital only made 185 seed-round deals; Contrast this with the SBIR/STTR program that makes almost 5,000 awards each year. Also, venture investments are principally made in two states, California and Massachusetts, and are concentrated in very few industries. 85 percent of VC funding is provided to just five states, and 60 percent of the total funding goes to California. For most small business in most of the nation, then, venture capital it not a realistic option to grow and commercialize their inventions.

Other countries have taken advantage of our imbalance to reduce America's technology lead, driven by more directed STEM-driven economic development mandates, lower labor costs, and building on American science. For example the European Union has now increased to over 16.9% the target R&D proportion provided directly to small businesses, about five times America's overall 3% of Federal R&D expenditures (the majority from SBIR). Seventeen other countries have copied the SBIR program in their countries. The Federal SBIR program seeks to release our innovation pipeline imbalance, unleashing entrepreneurial drive to create future jobs. SBIR combines agency-identified mission priorities with small business entrepreneurially-driven innovation, led by risk-taking entrepreneurs and private sector research leaders (often from universities or other large research organizations), and advancing our nation's basic science into novel applications and products.

The SBIR program targets this current bottleneck in America's innovation pipeline. Results have shown the high payoff from focusing a very small portion of the Federal R&D budget upon agency-identified challenges to unleash the entrepreneurially-driven energies of our small businesses. These businesses are led by risk-taking small business entrepreneurs and research leaders, often originally from universities or other large research organizations. 60% of SBIR projects involve at least one founder with a university background, and formal small business-university SBIR collaborations are growing, now at 35-50% depending upon agency. All STTR projects involve collaborations between small businesses and research institutions. Our small high tech businesses are driven to commercialize and grow, and efficiently convert science into innovation and jobs needed for our tech economy. The result is SBIR's high innovation productivity: using only 3.4% of the external R&D budget (1.7% of the budget overall) to produce 22-25% of the major innovations, 5500 patents/year, and a stream of new products, services, and high quality jobs.

The U.S. needs more small business-driven innovation to help build a stronger America that can continue to out-compete the world. Small businesses by their entrepreneurial private sector nature do this well, creating over two- thirds of the net new jobs in the past 15 years. America needs more SBIR awards to transition more science and technology to innovations, patents, products and high quality jobs.

2.3 SBIR/STTR and Collaborative Economics

If Silicon Valley gave the world the winning concept of "collaborative advantage", it's fair to say that SBIR/STTR takes that concept operational nation-wide through a collaborative model that links small and large business, government labs, universities and other technology stakeholders. These collaborations on SBIR/STTR projects address current and future American technology needs while establishing a vibrant regional root structure of productive and well-paying STEM-derived jobs and revenues, supporting American economic vitality. And the attainment of significant Phase III outcomes relies upon the entrepreneurial energy and investments of the small businesses in advancing their SBIR results towards commercial sale.

2.4 Broadening the Impact:

Sensing that SBIR/STTR benefits weren't equitably distributed throughout America, Congress acknowledged this in its 2011 SBIR/STTR reauthorization, mandating outreach to underserved populations and regions and related improvements to ensure greater SBIR/STTR commercialization outcomes consistent with continued reliance upon merit decisions in selecting proposals.

In response, SBIR/STTR used special administrative funding from the statute to launch "SBIR Road Tours: Seeding America's Future Innovations" in nearly 20 states, in a concerted effort to spread program benefits nation-wide. In parallel, the Dept. of Commerce launched 35 tech-focused "Rapid Innovation Clusters" – many in greater Rust Belt regions. And numerous universities began forging regional partnerships to commence "innovation institutes" to navigate STEM entrepreneurs through the startup "Valley of Death". Further, in some Rust Belt states where the return of traditional blue-collar manufacturing jobs is problematic, "innovation corridors" are springing up to grow emerging industry opportunities in new fields such as robotics, additive manufacturing and bioscience that offer high value jobs for the future.

This outreach is still new, but is showing potential for broadening the impact of SBIR across all of America. While the issue is partly the result of the general STEM issue, opportunities offered by the SBIR/STTR program together with improved outreach can also be used to help advance America's STEM initiatives.

3. Recommendations

Federal legislative and agency action could remove roadblocks restraining full achievement of SBIR/STTR potential, and prepare the path forward to American economic revitalization. The small business community, which creates most American new jobs and makes up 99.7% of U.S. firms, asks Congress to take the following actions to strengthen American competitiveness and jobs and to maximize the SBIR/STTR effectiveness:

A. Substantially increase the SBIR/STTR allocation of Federal R&D. This will increase innovation development and increase the impact on the economy, at no increase to the Federal R&D budget.

B. Keep America in the forefront of high technology by growing America's long term investment in R&D.

C. Insist that the SBIR/STTR statute's Phase III emphasis (and SBA Policy Directive implementation guidance) be fully implemented by all federal agencies with SBIR/STTR programs.

1. Ensure that all agencies have policies supporting the SBA Policy Directive on SBIR/STTR, promulgating Congress's intent under SBIR legislation.
2. Modify 15 USC 638 to require full implementation of SBIR/STTR Phase III rules, to further reinforce the "to the greatest extent practicable" requirement.
3. Federal agencies' Phase III actions should be taken as required by law – "to the greatest extent practicable", and should be tracked fully, in real-time, and reported by agencies and prime contractors.
4. The Federal Acquisition Regulations, FAR agency supplements, procurement manuals and procedures should be revised to implement the 2011 SBIR/STTR statute, with training and oversight procedures developed and executed to ensure implementation.
5. Create goals and make incentives available to agency Program Managers, Contracting Officers, ACOs, Contracting Officer Representatives, prime contractors and others to ensure proper recognition and pursuit of SBIR/STTR objectives.
6. Revise the law to require that at least 25 percent of the members of the Defense Business Board represent small businesses.
7. Require that the military departments use part of their 3% money to provide expedited security clearances for SBIR companies during early (pre-classified) research programs to prepare new small firms for classified work and accelerate incorporation of new technologies into weapons programs.

D. Reduce paperwork/administrative burden relating to proposals, contract administration and accounting, and reconsider financial restrictions placed on SBIR awardees.

1. Proposal requirements are becoming increasingly time-consuming and inflexible, boosting costs while creating administrative hurdles separate from the primary purpose of seeking high quality innovation.
2. Contract requirements are heavily burdensome especially for small SBIR businesses. Requirements streamlining will access a broader range of potential innovators while reducing red tape and paperwork burdens on the work.
3. Increasingly SBIR awardees are facing financial restrictions in the forms of requirements for meeting large company accounting rules and at some agencies in overhead restrictions set to exclude the highly capable and integrated small businesses that characterize advanced innovation. Acceptance of simplified but accurate accounting procedures and contract vehicles as well as eliminating overhead caps will help meet the rapid pace of modern innovation while better focusing on the work itself.

E. Retain the DoD Rapid Innovation Fund (RIF) program exclusively for its original purpose of DoD SBIR Phase III transition, and develop similar programs for other agencies.

1. Continue the originally proposed $500M in RIF funding solely for SBIR Phase III work.
2. Initiate a new stimulus program for "Fly-Over" non-VC states, funding an additional $1B stimulus to SBIR companies in non-VC dominant states (other than California, Massachusetts, New York, Texas, Washington State, and Washington DC) for 500 - $2M Phase III SBIR programs.
3. Since every $1 invested in SBIR returns $1.46 back in Federal taxes, it should be clear that SBIR is a net addition to the tax base and thus an overall reducer of the deficit and national debt.
4. More generally, reconsider non-procurement agency practices that fail to track Phase III success metrics, provide inadequate Phase III policy or transition follow-up, and discourage small business participation in non-SBIR regular R&D programs, such as barriers to contracting, high administrative burdens on proposals and contracts, and cost-sharing requirements.

F. Maintain strong intellectual property protection for SBIR/STTR innovations throughout Phases I-III.

1. With intellectual property a primary small business asset, patent law changes to support patent development and issuance to innovators as well as patent valuations will help justify increased entrepreneur and outside investment. Patents protect American jobs, and patent reform must ensure that small business innovation is not crushed by the interests of large businesses. Small business innovation and its resulting patents are core drivers for America's high value production and standard of living. The small business technology sector must be given a voice in the development of such laws.
2. Protect the proper allowability of patent expense in SBIR awards.

G. Require the agencies create small business goals for their Federal R&D expenditures.

H. Allow agencies currently not currently included in SBIR (e.g. the VA, iARPA) to join the program.

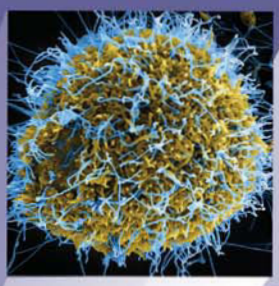
America remains the world's powerhouse of science, entrepreneurship and innovation. But the world is at our heels, seeking also America's economic dream, and competing hard to gain it with increasing investments in education, R&D and industrial development, and from a much lower wage base. For America to hold and grow its position, we need to reinvigorate our investment in our economic effectiveness and in the drivers that have built our economy: science, R&D, a highly educated workforce, entrepreneurship, innovation, intellectual property, and private enterprise. The SBIR/STTR program offers a well-tested and demonstrated base addressing national technology challenges and enlisting American small business entrepreneurs, scientists, engineers and STEM workers to convert our strong basic science into innovations to re-energize our core industrial and service industries. The recent studies show this effectiveness, and start to quantify the remarkably strong response it is causing in our economy, building new businesses, creating new products and services, and growing high quality jobs. We invite Congress to build upon this entrepreneurial Federal program to help further build America.

❖ *Please send any inquiries to alec@sbtc.org*

THE AIR FORCE IMPACT *to the* ECONOMY *via* SBIR/STTR

U.S. AIR FORCE

Air Force SBIR/STTR




SMALL BUSINESS

2014 ECONOMIC IMPACT STUDY

SMALL BUSINESS INNOVATION RESEARCH | SMALL BUSINESS TECHNOLOGY TRANSFER

the PURPOSE *of the* STUDY

This study was undertaken to quantify the Air Force SBIR/STTR Program's overall contribution to the national economy and nation's defense mission.[1] The study examined the economic outcomes and impacts from all Air Force SBIR/STTR Phase II awards completed during the 2000-2013 period. It was intended to answer the following basic question: What resulted from the Air Force's SBIR/STTR research and development (R&D) investment of nearly $4 billion,[2] provided to 1,750 companies in 4,524 separate SBIR/STTR contracts?

The study's three primary objectives were:

1 To determine the extent to which the Air Force SBIR/STTR Program has contributed to new economic activity and job creation in the United States.

2 To assess its effectiveness in generating new technology for U.S. military use.

3 To identify and highlight notable success stories resulting from this program.

The Air Force SBIR/STTR Program commissioned the study.

2014 ECONOMIC IMPACT STUDY

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U.S. AIR FORCE

Air Force SBIR/STTR

[1] *SBIR and STTR are acronyms respectively for Small Business Innovation Research and Small Business Technology Transfer. The two programs are similar; however, the much smaller STTR programs require small businesses to formally collaborate with not-for-profit research institutions, such as universities. See www.sbir.gov.*

[2] *The actual amount was $3,990,545,480.*

NATIONAL ECONOMIC IMPACTS

from the
Air Force SBIR/STTR Program
2000-2013

This study quantifies the Air Force SBIR/STTR Program's overall contribution to the nation's economy and defense mission.

It examines the economic outcomes and impacts from all Air Force Phase II awards completed during the 2000-2013 period, providing definitive answers to the question: What resulted from the Air Force's SBIR/STTR investment of nearly $4 billion, awarded to small U.S. companies in 4,524 contracts?

The research team contacted all 1,750 companies with Air Force SBIR/STTR Phase II contracts completed during the FY 2000-2013 period. Companies were asked to divulge the total sales of new products and services directly related to their Air Force SBIR/STTR Phase II contracts. They were also asked about their related sales to the U.S. military, follow-on R&D contracts, licensing revenue, and sales by licensees and spin-out companies. The response rate was over 96 percent. The research team was able to obtain conclusive information on the outcomes of 4,346 contracts out of a total of 4,524 total.

Well over half of the Air Force Phase II contracts— 58 percent—resulted in sales of new products and services based on the innovations developed with these contracts. Companies reported the following direct commercialization-related outcomes from their Phase II contracts:

HUGE R.O.I.

58%

Of Phase II contracts resulted in sales of new products and services based on the innovations developed with these contracts.

$14.7B

In total sales of new products and services, including **$4.4 billion** in military product sales.

$1.9B

In outside investment from venture capital,angel, & other private-sector funding sources

225

COMPANIES

Acquired by larger corporations

180

TECHNOLOGIES

Licensed to other companies for commercialization

125

NEW SPIN-OUT COMPANIES

To commercialize Air Force-funded innovations

The research team used IMPLAN economic-impact assessment software to estimate the total economic impacts related to both the $4 billion in Air Force SBIR/STTR Phase II contracts and subsequent $14.7 billion in sales of new technologies. **Results included:**

$47.9B **Total economic output nationwide**

$24.7B In value added, representing new wealth creation in the economy

$15.5B In labor income

16,751 Average new full-time jobs per year, with an average wage of **$65,968**

The study was commissioned by the Air Force SBIR/STTR Program. It is the first-ever comprehensive study of the economic impacts of an entire federal SBIR/STTR program. The study was conducted by TechLink, a federally funded technology transfer center at Montana State University-Bozeman, in collaboration with the Business Research Division (BRD) of the Leeds School of Business at the University of Colorado Boulder.

THE AIR FORCE SBIR/STTR PROGRAM IN CONTEXT

Federal SBIR programs date back to 1982 and were created to harness the innovativeness of U.S. small business—both to help meet the high-priority technology needs of the federal government and to benefit the national economy. Establishment of these programs was part of a larger effort in the United States during the early 1980s to make strategic government R&D investments to counter the loss of national economic competitiveness and related budget deficits.

In the enabling legislation, the Small Business Innovation Development Act of 1982,[3] Congress affirmed that technological innovation creates jobs and increases productivity, competitiveness, and economic growth. It also recognized that small businesses are the principal source of innovation in the United States and are generally more cost-effective in conducting R&D than major corporations, universities, and government laboratories. Finally, Congress asserted that, compared to these other entities, small businesses are more capable of converting R&D results into new products. However, it recognized that small businesses face greater difficulty securing funding for R&D and commercialization. Based on these findings, the Act was intended to (1) spur technological innovation in the United States; (2) help meet federal R&D needs; and (3) increase private sector commercialization of innovations resulting from federally funded investments.[4]

All federal agencies with extramural R&D budgets that exceed $100 million, currently eleven agencies, are required to allocate a small portion of their R&D budgets— 2.9 percent in FY 2015—to SBIR. In addition, the five federal agencies with extramural R&D budgets exceeding $1 billion (the Department of Defense, Department of Energy, Department of Health and Human Services, NASA, and National Science Foundation) are required to expend 0.4 percent (FYs 2014 and 2015) of their extramural R&D budgets for STTR.

Each agency determines its own R&D topics, issues solicitations, accepts proposals from small businesses (defined as for-profit entities with not more than 500 employees), establishes evaluation processes for these proposals, and makes awards on a competitive basis. The Small Business Administration (SBA) functions as the overall coordinating agency for both SBIR and STTR.

[3] *Text available at the following URL: http://history.nih.gov/research/downloads/PL97-219.pdf.*

[4] *A fourth objective, "to foster and encourage participation by minority and disadvantaged persons in technological innovation," was added as the bill was being finalized.*

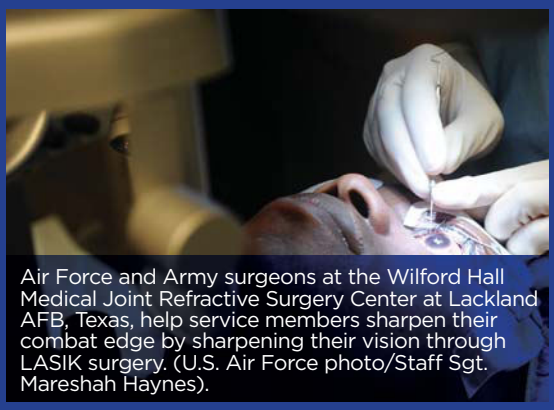
[5] *In FY 2012, the Air Force SBIR/STTR Program had a $345 million budget, versus $119 million for the National Cancer Institute.*

There are three phases to SBIR/STTR programs. Phase I funds short-term (typically six-month) feasibility studies of proposed innovations. These awards normally do not exceed $150,000. Assuming that a company establishes the scientific and technical merit as well as the commercial potential of its proposed innovation, it can compete for follow-on Phase II funding. Phase II funds the further development, testing and/or evaluation, such as by creation of a prototype, of the proposed innovation. Phase II awards normally do not exceed $1,000,000 and are typically for a two-year R&D effort. During Phase III, companies pursue commercialization, which can include transitioning to government acquisition programs, of technologies successfully developed during the previous two phases. No additional SBIR/STTR funding is available for this phase, but some federal agencies provide supplemental, non-SBIR/STTR funding for further development of promising innovations to meet critical U.S. government technology needs.

Approximately $2.3 billion is awarded annually through the federal SBIR/STTR programs. The Department of Defense (DoD) is the largest participant, with approximately $1.2 billion in SBIR/STTR contracts annually. Within DoD, the Air Force has the largest individual program. Its SBIR/STTR Program accounts for approximately 32 percent of the DoD total and 15 percent of the entire federal SBIR budget. Only the National Institutes of Health (NIH) has a larger combined SBIR program than the Air Force. However, the Air Force program is well over twice the size of the largest NIH component, the National Cancer Institute.[5]

SEEDING SUCCESS

Improved Eye Surgery



Air Force and Army surgeons at the Wilford Hall Medical Joint Refractive Surgery Center at Lackland AFB, Texas, help service members sharpen their combat edge by sharpening their vision through LASIK surgery. (U.S. Air Force photo/Staff Sgt. Mareshah Haynes).

LASIK, or laser-assisted in situ keratomileusis, is by far the most popular method of corrective eye surgery for conditions such as farsightedness, nearsightedness, and astigmatism. The procedure traditionally has used a microkeratome surgical blade to cut a flap in the outer layer of the eye, which is then folded back to expose the underlying cornea. However, blades have been associated with LASIK complications such as uneven edges and incomplete flaps.

With Air Force SBIR/STTR Program funding, Irvine, California-based IntraLase developed a bladeless system that replaces the surgical blade with a remote-controlled, high-precision, femtosecond (FS) laser to cut corneal flaps. Originally intended for use on Air Force pilots, this innovation has improved the quality and safety of eye surgeries worldwide. The IntraLase FS Laser System creates accurate and consistent flaps with fewer complications and is regarded as the safest, most advanced method of cutting corneal flaps today.

Over 5 million surgeries have been performed using the IntraLase system, and this system is now employed in half of all LASIK procedures in the U.S., including all LASIK eye surgeries performed by the U.S. military. In 2007, IntraLase was acquired by Advanced Medical Optics, a company owned by Abbott Medical Optics.

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Importance Of Study

As a result of the Air Force SBIR/STTR Program's commanding size and funding of innovations in virtually all technology fields (including advanced materials, communications, electronics, energy and power, medical technologies, and software), this program offers a good case study of the economic outcomes and impacts of the entire federal SBIR/STTR enterprise. It is important to understand these economic outcomes and impacts. They are essential for determining how well the nation's major investments in SBIR and STTR are meeting their intended goals: spurring technological innovation, helping meet federal R&D needs, and increasing private-sector commercialization of innovations.

Surprisingly few studies have examined the economic outcomes and impacts of the federal SBIR/STTR programs. Most SBIR-related research has focused on issues such as the effectiveness of government programs in spurring innovation. In 2014, NASA published a report on the economic impact of its SBIR program in fiscal year 2012.[6] However, this report only examined the economic impacts of the actual SBIR funds provided to small businesses, and did not include the impacts resulting from the innovations generated through this program.

The closest antecedents to the present study are a series of reports by the National Research Council (NRC) that were issued beginning in 2007. When Congress reauthorized SBIR in 2000, it asked the NRC to assess the effectiveness of this nearly twenty-year-old federal initiative. In response, the NRC examined the SBIR programs of the five major funding agencies: DoD, NIH, NASA, the Department of Energy, and the National Science Foundation.[7] Together, these agencies account for approximately 96 percent of all SBIR/STTR funding. The NRC studies were intended to assess whether these agency programs were meeting their Congressional objectives by evaluating their outcomes, including the degree to which the SBIR/STTR research resulted in commercialization, this research's value to the agency's mission, and its overall economic and other benefits. The first round of NRC studies, which appeared in the latter-2000s, is now being followed by a second round resulting from Congress's reauthorization of SBIR in 2011.[8]

[6] *National Aeronautical and Space Administration, 2014, SBIR/STTR Economic Impact Report, FY 2012, Washington, DC: NASA.*

[7] *National Research Council, 2008, An Assessment of the SBIR Program at the National Science Foundation, Charles W. Wessner, ed. Washington, DC: The National Academies Press; National Research Council, 2008, An Assessment of the SBIR Program at the Department of Energy, Charles W. Wessner, ed. Washington, DC: The National Academies Press; National Research Council, 2009, An Assessment of the SBIR Program at the National Institutes of Health, Charles W. Wessner, ed. Washington, DC: The National Academies Press; National Research Council, 2009, An Assessment of the SBIR Program at the Department of Defense, Charles W. Wessner, ed. Washington, DC: The National Academies Press; National Research Council, 2009, An Assessment of the SBIR Program at the National Aeronautics and Space Administration, Charles W. Wessner, ed. Washington, DC: The National Academies Press*

[8] *The first in this new round focuses on DoD: National Research Council, 2014, SBIR at the Department of Defense, Washington, DC: The National Academies Press.*

[9] *National Research Council, 2014, SBIR at the Department of Defense, Washington, DC: The National Academies Press, p. 256.*

The current study differs from the NRC's SBIR studies in the following key ways:

1 The NRC studies sampled the commercialization results of companies in each agency SBIR program in order to infer the program's overall level of commercialization success. By contrast, the current study examines the cumulative commercialization success of the entire Air Force SBIR/STTR program during the selected time period—the total sales of all new products and services and other major economic impacts directly related to the innovations that this program has generated.

2 The NRC studies used a multi-faceted approach to assess commercialization results, including surveys of Phase II recipients that employed a two-tier sampling methodology: random samples encompassing 20 percent of the companies with three or more SBIR awards (70 percent of the total awards) and 100 percent of the companies with 1 to 2 awards (30 percent of the total). By contrast, the current study surveyed 100 percent of all Phase II recipients that completed Air Force SBIR/STTR Phase II contracts during the chosen time period.

3 The NRC surveys of commercialization success had a much lower response rate than the present study. For example, the effective response rate of the DoD Phase II recipients in the 2014 NRC study was 28.5 percent.[9] By contrast, the present study had a response rate of over 96 percent. The much lower response rate of the NRC study introduces multiple sources of potential bias that are largely avoided by the high response rate of the current study.

4 The NRC studies did not attempt to assess the overall impacts on the national economy of the agency SBIR programs that they studied. The current study does. By employing the national IMPLAN model, a well-established economic-impact assessment tool, it estimates the economic impacts directly related to both the Air Force SBIR/STTR Phase II contracts themselves and also to the subsequent commercialization of the innovations developed with this funding. These impacts include total economic output, employment, labor income, and value added.

In Conclusion

This study is a first-ever comprehensive study of the economic impacts of an entire federal SBIR/STTR program. It examines the economic impacts resulting not only from the infusion of Air Force SBIR/STTR funding throughout the United States for R&D on topics of interest to the Air Force, but also the national economic impacts from the sales of new products and services derived from the innovations that resulted from this R&D. It provides a comprehensive answer to the guiding question:

What economic impacts resulted from the Air Force's investment of $4 billion in R&D projects by 1,750 small businesses during the FY 2000-2013 period?

Research Team

This economic-impact study was conducted by TechLink, a federally funded technology transfer center at Montana State University-Bozeman, in collaboration with the Bureau Research Division (BRD) of the Leeds School of Business at the University of Colorado Boulder. Since 1999, TechLink has served as DoD's primary national "partnership intermediary," helping to develop technology transfer partnerships between DoD laboratories and U.S. industry nationwide. TechLink's primary focus is helping DoD labs to transfer their inventions to U.S. companies through license agreements. TechLink currently brokers or facilitates approximately 60 percent of all DoD license agreements with industry. These license agreements enable companies to develop, manufacture, and sell new or improved products and services using DoD inventions. (For more information, see www.techlinkcenter.org.) TechLink previously has conducted three national studies of the economic impacts resulting from DoD technology transfer.[10]

The Business Research Division (BRD) at the University of Colorado's Leeds School of Business has been analyzing local, state, and national economies for more than 95 years. The BRD specializes in economic-impact studies and conducting customized research projects that help companies, associations, nonprofits, and government agencies make informed business and policy decisions. It produces the annual Colorado Business Economic Outlook, which provides a forecast of the state's economy by sector, the quarterly Leeds Business Confidence Index, and the quarterly Colorado Business Review. (For more information, see www.colorado.edu/leeds/centers/business-research-division.)

The principal authors of this study were Dr. Will Swearingen and Ray Friesenhahn of TechLink and Brian Lewandowski and Dr. Richard Wobbekind of the BRD. Chris Huvaere, Chandra Morris, Phillip Luebke, Andrew Schoneberg, Christie Bell, and John Verostek were other key members of the TechLink team.

[10] *The most recent of these studies was in 2012: National Economic Impacts from DoD License Agreements with U.S, Industry, 2000-2011, available online at http://techlinkcenter.org/articles/2013-report-economic-impact-dod-invention-licensing.*

(Photo: U.S. Air Force photo/Airman 1st Class Chris Drzazgowski)

Methodology

This study was undertaken in three major phases. First, during the Data Gathering phase, the research team contacted all companies that completed Air Force SBIR/STTR Phase II contracts during the FY 2000-2013 time frame. Companies were asked to divulge the total sales of new products and services and other economic results directly related to these SBIR/STTR contracts. This phase lasted for eight months and ran from April through November 2014. Second, during the Data Analysis phase, the research team analyzed the information gathered and used IMPLAN economic-impact assessment software to estimate the total economic impacts resulting from (1) the initial Phase II funding for R&D, and (2) subsequent sales of new products and services derived from the innovations generated by the R&D. This second phase took five months and extended from October 2014 through February 2015. Finally, the Final Report Generation phase extended over the first quarter of 2015. A timeline of the study is depicted below in Table 1. Specific activities undertaken during the first two phases are subsequently described.

Table 1: Timeline of the Air Force SBIR/STTR Program's Economic-Impact Study

PHASES	APR 2014	MAY 2014	JUN 2014	JUL 2014	AUG 2014	SEP 2014	OCT 2014	NOV 2014	DEC 2014	JAN 2015	FEB 2015	MAR 2015
DATA GATHERING	■	■	■	■	■	■	■	■				
DATA ANALYSIS							■	■	■	■	■	
FINAL REPORT										■	■	■

(Photo: U.S. Air Force photo/Senior Airman Donald Acton)

Data Gathering

To undertake this study, TechLink first assembled essential information on all Air Force SBIR/STTR Phase II contracts that were completed during the FY 2000-2013 period. The study focused exclusively on Phase II contracts because Phase I contracts by themselves rarely lead directly to innovations that can be commercialized; instead, they investigate the feasibility of new technology concepts that can subsequently be developed during Phase II. Information on the Phase II contracts came from the Air Force SBIR/STTR awards database.[11] A total of 4,524 Phase II contracts were included in the study.

The essential information gathered for each Phase II contract was entered into a custom database that was developed for this study, to facilitate data gathering and analysis. Essential Phase II contract information included the company name and location, the contract number and award amount, the start and completion dates of the award, names and contact information for the principal investigator and company executive at the time of the award, and award titles and abstracts, which provided background information on the technology being developed.

In addition, a secondary database was created listing all SBIR and STTR awards, from any agency, that had been given to the Air Force Phase II recipients included in this study. This was to allow the research team and company representatives being interviewed to better distinguish results from the specific Air Force contract under review from the companies' other SBIR/STTR awards. It also permitted later secondary analysis of company commercialization performance compared to their overall success in winning SBIR/STTR awards. This database included 62,828 SBIR/STTR awards out of the SBA's total listing of over 146,000 awards. A total of 131 companies in this study had received 100 or more total SBIR/STTR awards (Phase I and Phase II, any agency), with one company having secured over 1,500 total SBIR/STTR awards.

A team of four TechLink economic research specialists used the Phase II information and databases to contact each of the companies involved. They attempted to contact by email and telephone all 1,750 Phase II recipients about the outcomes of their 4,524 Air Force Phase II contracts. The number of contracts exceeds the number of companies because a sizeable subset of companies included in the study (830, or 47 percent) had two or more Air Force SBIR/STTR Phase II contracts. Of this group, 504 companies (29 percent) had three or more Air Force Phase II contracts, 340 (19 percent) had four or more contracts, and one company had 54 total Air Force Phase II contracts. This data-gathering phase lasted from April through November 2014.

[11] *Available online at http://www.afsbirsttr.com/TechSearch/Default.aspx.*

Survey Questions

Companies were asked a series of questions that focused on the economic outcomes and impacts related to their Air Force SBIR/STTR Phase II contracts. They were assured that their responses would be treated as confidential information and that, in order to conceal their identity, their responses would be aggregated with the responses of other companies and submitted to the Air Force without any company names.

Basic questions included the following:

1 Did your company develop any new products or services based on your Air Force SBIR/STTR Phase II contract(s)? If so, what were the total cumulative sales of these new products or services for each contract?[12]

2 Of the total sales for each Air Force Phase II contract, what was the dollar value of sales to the U.S. military, either directly or through a prime contractor?

3 Did the Phase II contract(s) lead to any follow-on R&D contracts for further development of the technology or technologies resulting from Phase II? If so, what was the total dollar value of these contracts?

4 Did you license any of the technologies developed with Air Force Phase II funding to another company? If so, what were the total royalties received from each licensee? What is the name of the licensee, so we can follow up to ask it about its sales?

5 Did you create a spin-out company to commercialize any of the technologies developed with Air Force SBIR/STTR Phase II funding? If so, what is the name of the company, so we can ask it about its sales?

6 Did you receive any significant subsequent investment funding, such as venture capital or angel funding, directly related to the technology developed or commercialized? If so, what was the total amount of these investments?

7 Was your company acquired as a direct result of the technology or technologies developed with Air Force SBIR/STTR Phase II funding? If so, what was the acquisition amount?

[12] *Companies were not asked to report their sales by year because this would have greatly increased the burden of responding to the survey and, consequently, lowered the response rate.*

Response Rate OVER 96%

The response rate was over 96 percent. The research team was able to obtain definitive information on the outcomes of 4,346 contracts out of the 4,524 total. This equals an effective response rate of slightly over 96 percent with regard to the contracts. Only 64 of the Phase II recipient companies, with a combined total of 120 contracts, openly refused to participate or were non-responsive, despite multiple efforts to secure the necessary information. They represent only 3 percent of the 1,750 companies in the study, yielding an effective company response rate of 97 percent.

An additional 32 companies, with a combined total of 58 contracts, could not be contacted because they had ceased to operate as corporate entities. These companies had gone out of business, changed their names, or been acquired by other companies and had left no trails that could be followed. Rigorous attempts were made to track down individuals who might know about the outcomes of their Phase II contracts. In a few cases, these efforts were successful. However, 32 companies had left no traces.

The primary reasons for the study's high response rate are believed to be the following:

Clear communication about the purpose and legitimacy of the study.

Companies were informed that the study's purpose was to quantify the extent to which the Air Force SBIR/STTR Program was having a positive impact on the national economy and U.S. defense mission, and that the results would be communicated to Air Force policymakers, other government agencies, Congress, and the U.S. public. Companies that questioned the legitimacy of the study were sent a letter from the Air Force SBIR/STTR program manager that explained the purpose, confidential nature, and importance of the study as well as TechLink's role in undertaking it.

Strong assurance that company-specific information would be kept confidential.

Companies were assured that the Air Force was only interested in the overall economic impacts from its SBIR/STTR Program—not in company-specific results. Most companies consider their sales figures to be confidential, proprietary, or business-sensitive. Without the assurance that all responses would be treated as confidential information, few companies would have been willing to divulge their sales information.

Extensive research to find current contact information.

Because of the long time span covered by the study and the impermanent nature of many small R&D companies, the contact information for principal investigators and company executives in the Air Force SBIR/STTR awards database was no longer valid in many cases. Among other things, telephone area codes had changed; companies had gone out of business, moved, or merged with other firms; and the key people had changed positions, moved to other companies, retired, or even died. The research team expended extensive time and effort to find people knowledgeable about the outcomes of the Air Force SBIR/STTR Phase II contracts.

Persistence by the TechLink economic research specialists.

Some companies were contacted more than a dozen times by email or telephone in the attempt to get through to the right person and obtain the necessary information. Several different approaches were tried to secure compliance from recalcitrant companies, including having other team members contact the company, approaching different company personnel, and sending a request by registered mail.

Conciseness of the survey.

The survey questions were few in number and relatively easy to answer. In many cases, the research team was able to secure the necessary information over the telephone on the first contact. More commonly, extensive follow-up by phone and email was required, often involving several different company personnel. However, the conciseness of the survey encouraged participation.

SEEDING SUCCESS

Secure Fingerprint Biometric

An Air Force Security Forces airman conducts a random biometrics systems check as part of the Air Force base's antiterrorism measures. The check matches identification-card holders with their fingerprints. (U.S. Air Force photo/Senior Airman Andria J. Allmond).

Fingerprints have been used to identify people since the early 1900s and are still a leading biometric today. Apple Computer's iPhone 5s, for example, has a Touch ID sensor that can be used to limit access to the device. However, fingerprint verification is plagued with the problem of "spoofing." Prints can be easily lifted for criminal purposes with gelatin or a latex mold, and digits of deceased individuals can also be effectively used.

An Albuquerque, New Mexico-based biometrics identification firm, Lumidigm, addressed the problem by developing a fingerprint authentication system with Air Force SBIR funding. This technique uses multispectral imaging to capture an individual's unique fingerprint image, including characteristics under the skin, to determine if the tissue fingerprinted is live.

Today, Lumidigm fingerprint sensors are used globally for authentication in the banking, healthcare, government, transportation, and retail sectors. The company's annual growth rates have been above 30 percent for the past decade. Lumidigm is now owned by HID Global headquartered in Austin, Texas.

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NAICS Code Assignments

TechLink next assigned each Phase II recipient company to the appropriate 6-digit North American Industry Classification System (NAICS) code or codes specific to that company or commercial outcome. This was an essential step for analysis of the overall economic impacts. NAICS codes are one of the most important inputs to the economic-impact model, IMPLAN (described below), because they are used to accurately determine the economic multipliers specific to the particular industrial activity. NAICS is the U.S. federal government's standard industry classification system. It is a comprehensive production-oriented system that groups companies and divisions of companies into industries based on the activities in which they are primarily engaged. NAICS recognizes 1,065 different industries in the United States and assigns a unique code to each industry.

For analysis of the economic impacts resulting from the Air Force SBIR/STTR Phase II R&D activity itself, all companies in this study were assigned to NAICS code 541712, titled "Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)."[13] In addition, companies that had commercialized the results of this R&D were assigned a second NAICS code for analysis of sales of the specific product or service. Companies with multiple Air Force SBIR/STTR contracts generating sales were frequently assigned to more than one NAICS code. For example, if a company developed an innovative laser with Air Force SBIR/STTR Phase II funding, then manufactured and sold this laser and, in addition, received a follow-on R&D contract to further develop the laser for a specific aerospace application, it would be assigned two different NAICS codes, one specific to the manufacturing and another for the R&D activity.

To identify the appropriate NAICS codes, multiple sources were referenced, including Hoover's (www.hoovers.com), the LexisNexis Academic web site (www.lexisnexis.com), a commercial NAICS-related website (www.naics.com) that provides a convenient system for looking up NAICS codes by industry sectors and subsectors, and the federal System for Award Management (www.sam.gov), which contains NAICS codes self-identified by the companies. For businesses not listed on these sites, the classification tree at the official U.S. government's NAICS code website (http://www.census.gov/eos/www/naics/) was compared to activity reported by the companies in their interviews with the TechLink team to arrive at the appropriate NAICS codes. (See Appendix 1 for a list of all NAICS codes assigned to companies in this study.)

The TechLink research team entered company sales and other economic data and NAICS code information into the custom database developed for this study. The database greatly facilitated data entry from the multiple economic research specialists gathering company information. Once the data were aggregated and carefully validated by the team, the database provided mechanisms for quickly querying and analyzing the data as well as generating a final dataset for economic-impact modeling.

TechLink subsequently submitted the final dataset to the Business Research Division (BRD) at the Leeds School of Business, University of Colorado Boulder. The dataset included—for each Air Force SBIR/STTR contract that had achieved sales (including royalties from licensing)—a code number to identify the agreement and conceal the company's name, the 6-digit NAICS code for the corresponding product or service, and the total sales figures.

The "sales" category included all sales of new products and services directly related to the technologies developed with the Air Force SBIR/STTR funding, including military sales; follow-on R&D contracts to further develop these technologies for specific applications (defined as sales of R&D services); royalties from licensees of the technologies developed with the Air Force SBIR/STTR funding; licensee sales of the licensed Air Force SBIR/STTR-developed technologies, when this information could be obtained; and sales by spin-out companies of the Air Force SBIR/STTR-developed technologies, when this information was available.

[13] *This was the approach used in the 2014 NASA study: National Aeronautical and Space Administration, 2014, SBIR/STTR Economic Impact Report, FY 2012, Washington, DC: NASA.*

(Photo: U.S. Air Force photo/Airman 1st Class Chris Drzazgowski)

Data Analysis

The BRD employed a widely used economic-impact analysis software program, IMPLAN, to estimate the economic contribution effects of the total sales resulting from the Air Force SBIR/STTR Phase II contracts. More than 1,500 entities in academia, the private sector, and government use IMPLAN to model economic impacts. It is employed to determine economic impacts on regions ranging in size from zip code area to county, state, and national levels (www.implan.com).

IMPLAN draws on a mathematical input-output framework originally developed by Wassily Leontief, the 1973 Nobel laureate in economics, to study the flow of money through a regional economy. IMPLAN assumes fixed relationships between producers and their suppliers, based on demand, and that inter-industry relationships within a given region's economy largely determine how that economy responds to change. Increases in demand for a certain product or service causes a multiplier effect—a cascade of ripples through the economy. This increased demand affects the producer of the product, the producer's employees, the producer's suppliers, the supplier's employees, and others, ultimately generating a total impact on the economy that significantly exceeds the initial change in demand.

For example, Company X develops a laser-based eye surgery device with its Air Force SBIR/STTR Phase II contract, which it then manufactures and sells nationwide. This requires it to hire factory workers, who spend their payroll checks on groceries and other goods. In addition, Company X has to purchase components and raw materials from other companies, which also employ workers who purchase groceries and other goods, and so on.

In this example, direct effects are the sales of the eye surgery device developed with Air Force funding. Indirect effects are the inter-industry purchases of components and raw materials needed to manufacture this device. Induced effects are the household expenditures as workers spend their payroll checks on goods and services across a wide spectrum of the economy. Economic impacts are the sum of direct effects, indirect effects, and induced effects. Multipliers are the ratio of the overall economic impact to the initial change and are typically derived from the following equation: (direct effect + indirect effect + induced effect) / direct effect. Multipliers are very specific to industry sectors and regions. IMPLAN uses NAICS codes to distinguish between 536 industry sectors recognized by the U.S. Department of Commerce. Each sector has a unique output multiplier because it has a different pattern of purchases from firms inside and outside of the regional economy. Each year, IMPLAN is updated using data collected by various federal government agencies.

In this study, the BRD converted the NAICS codes provided by TechLink to the 536-sector IMPLAN input-output model, then applied this model to (1) the Air Force SBIR/STTR Phase II R&D activity, and (2) the total sales figures directly attributable to the sales of the innovations resulting from this activity. As previously indicated, these sales figures included all sales of products and services related to the Air Force SBIR/STTR Phase II contracts completed during the FY 2000-2013 period. Using IMPLAN, BRD was able to estimate the sum of the direct, indirect, and induced effects of these sales. The overall purpose of this modeling exercise was to estimate the total economic contribution of these sales to the nation's economy, including total economic output, value added, employment, and labor income.

Data presented are for the year 2013 accounting period and are expressed in 2013 dollars. The large majority of the company sales occurred prior to 2013 and some date back to the early 2000s. However, many of these sales are ongoing and there was a need to standardize the year. Use of 2013 as the reference year represents a conservative approach because it does not consider the relatively higher value of the earlier sales figures due to inflation: a dollar in 2013 was worth 35.3 percent less than a dollar in 2000.[14]

[14] *Per the U.S. Bureau of Labor Statistics Consumer Price Index (CPI) Inflation Calculator, available online at http://www.bls.gov/data/inflation_calculator.htm.*

(U.S. Air Force photo/Senior Airman David Owsianka)

Survey Results

Sales from Air Force SBIR/STTR Phase II contracts

Well over half of the Air Force SBIR/STTR Phase II contracts resulted in commercialization (see Table 2). Of the 4,524 Phase II contracts, 2,631 resulted in sales—a total of 58 percent.[15] Of the rest, 1,715 (38 percent) did not result in sales and 178 (4 percent) consisted of contracts awarded to companies that were unwilling to provide information or were no longer contactable because they had ceased to exist as corporate entities. Ultimately, the commercialization level achieved by these Air Force SBIR/STTR Phase II contracts may be significantly higher—it usually takes 2 to 8 years to convert a new technology into a product.

Total cumulative sales from the Air Force SBIR/STTR Phase II contracts were nearly $14.7 billion ($14,691,776,039). This equates to average sales of approximately $5.6 million for each of the 2,631 contracts that achieved commercialization. This sales figure is over 6 times the average contract amount of $882,084. The average sales per contract, when considering all of the Air Force Phase II awards, including those without commercialization success, was slightly over $3.2 million. This is 3.6 times the size of the average contract amount, demonstrating that the Air Force SBIR/STTR Program achieved substantial commercialization success from its funding of small R&D companies nationwide.

Table 2: Sales resulting from Air Force SBIR/STTR Phase II contracts, 2000-2013

AIR FORCE SBIR/STTR PHASE II CONTRACTS	Total Number Of Contracts	Percent of Total	Total Sales *$ Billions*
TOTAL CONTACTS	4,524	100	$14.692
Contacts With Sales	2,631	58	$14.692
Contacts Without Sales	1,715	38	—
Companies Not Responding	178	4	—

As previously noted, the "sales" category included all of the following sources of revenue from commercialization of the technologies developed with Air Force SBIR/STTR Phase II funding:

- Sales of new products and services, including both commercial (civilian) sales and sales to the U.S. military
- Follow-on R&D contracts to further develop these Air Force SBIR/STTR-developed technologies for specific applications (these were treated as sales of R&D services)
- Royalties accruing to the Air Force SBIR/STTR Phase II contract recipients from sales by licensees of the technologies developed with the Air Force funding
- Sales by licensees of the Air Force SBIR/STTR-developed technologies—when this information could be obtained
- Sales by spin-out companies that were commercializing the Air Force SBIR/STTR-developed technologies—when this information was available

Product and service sales. Table 3 shows the total sales from the Air Force SBIR/STTR Phase II contracts, broken down by sales category. As this table shows, commercial (civilian) product and service sales totaled slightly over $6.3 billion and accounted for 43 percent of the total sales. Military product and service sales were nearly $4.4 billion and constituted 30 percent of the total. However, they accounted for approximately 41 percent of the total product sales. This high level of sales indicates that the Air Force SBIR/STTR Program is achieving its objective of developing new technology to support the U.S. defense mission.

Table 3. Sales from Air Force SBIR/STTR Phase II contracts, by sales category

SALES CATEGORY	Total Sales *$ Millions*	Percent of Total
Commercial Product/Service Sales	$6,329	43
Military Product/Service Sales	$4,386	30
Follow-on R&D Contracts	$3,545	24
Royalties From Licensees	$60	0.5
Sales By Licensees	$268	2
Sales By Spin-Out Companies	$104	0.5
TOTAL	**$14,692**	**100**

[15] *This commercialization level is higher than the 48 percent reported for DoD SBIR/STTR Phase II projects as a whole in the NRC study, National Research Council, 2014, SBIR at the Department of Defense, Washington, DC: The National Academies Press.*

Follow-on R&D contracts, to further develop the technologies generated with Air Force SBIR/STTR funding, totaled around $3.5 billion and accounted for 24 percent of the total. This R&D funding came from the government and private sectors and included Phase III contracts as well as additional, directly related SBIR/STTR contracts from other federal government agencies.

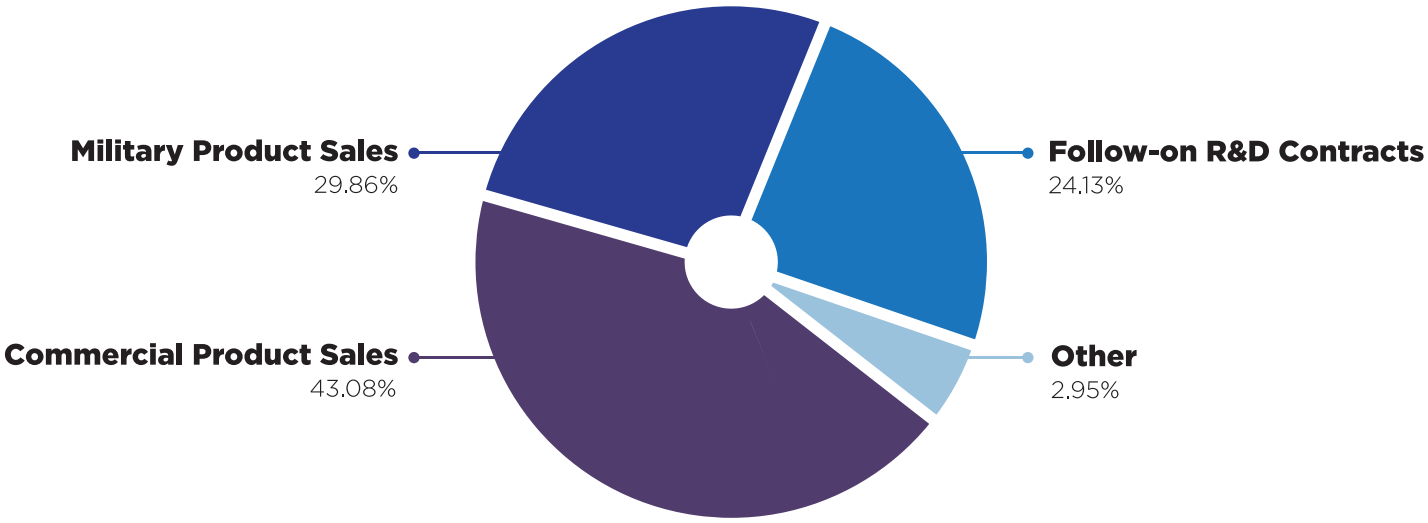
Other sales. Royalties resulting from licensee sales of the technologies developed with Air Force Phase II funding were around $60 million. Sales by licensees were reported to be $268 million. Sales by spin-out companies, of which there were 125, totaled $104 million. Together, the last three categories accounted for only 3 percent of the total sales.

The most productive SBIR/STTR Phase II contract generated nearly $1.5 billion in commercial product sales. This amount was nearly 3 times larger than sales from the second most successful Phase II contract, which generated approximately $560 million in commercial product sales. A total of 23 Phase II contracts had sales exceeding $100 million; 220 had sales exceeding $10 million; 1,151 had sales of more than $1 million; and 1,192 had sales larger than $882,084, which was the average size of the Air Force SBIR/STTR Phase II contract.

Virtually all of the $14.7 billion in sales was clustered in just three industry sectors. "Manufacturing" accounted for around $9.4 billion of the sales, or 64 percent. "Professional, Scientific, and Technical Services" accounted for some $4.2 billion, representing 29 percent of the total. "Information" accounted for slightly less than $1 billion, or nearly 7 percent. Together, these three sectors accounted for 99.6 percent of all sales.

Figure 1 below presents a more readily understandable summary of the total sales from all Air Force SBIR/STTR Phase II contracts that were completed during the FY 2000-2013 period, broken down by sales category.

Figure 1. Sales Results by Sales Category



Sales Figures Understate the Reality.

For several reasons, total sales figures obtained by this survey are probably significantly smaller than the actual total sales resulting from Air Force SBIR/STTR Phase II contracts completed during the 2000-2013 period. Reasons include the following:

Non-responding companies

Sales information was not available from a significant number of companies. As previously noted, 96 companies with a total of 178 Air Force SBIR/STTR Phase II contracts did not participate in the study—64 because they declined to participate and another 32 that were uncontactable because they had ceased to operate as corporate entities. Many of the non-compliant companies are believed to have substantial sales. For example, a sizeable number were large corporations that had acquired Phase II recipient companies because of the commercial strength of the technologies developed with Air Force SBIR/STTR funding.

Licensee underreporting of sales and underpayment of royalties

Another reason why the total reported sales, as well as the royalties from such sales, are believed to be substantially larger than this survey discovered is that underreporting is common in the licensing world. Historic royalty audit data from the Invotex Group, a well-established accounting and intellectual property management company, reveals that over 80 percent of licensees underreport and underpay royalties to their licensors.[16] There are various reasons why royalties are underreported. However, the Invotex Group found that at least half of the licenses it audited had underreported sales.

Licensee sales information generally unavailable

The total sales figures also underreport the reality because they do not include most of the licensee sales. Companies reported that they had licensed a total of 180 technologies. However, the TechLink team was able to obtain sales information for only 48 (27 percent) of these licensed technologies. Many companies declined to identify their licensees or to divulge what they knew of licensee sales. In cases where the licensees were identified and contact information was provided, the licensees proved to be resistant. For the most part, licensees did not feel obligated to participate in this study and were not responsive to requests for information on their sales.

Sales information for spin-out companies generally unavailable

The total sales figures do not include most of the sales by companies spun out of the Phase II recipient companies to commercialize the technologies developed with Air Force SBIR/STTR funding. A total of 125 companies reported that they had created spin-out companies. However, the TechLink team was able to obtain sales information for only 27 of these companies (22 percent). As in the case of licensees, most of the spin-out companies did not feel obligated to participate in this study and were not responsive to requests for information on their sales.

Inflation

Finally, inflation contributes, in effect, to an under-valuation of sales. All sales data are expressed in 2013 dollars as previously discussed. However, some of the company sales date back to the early 2000s and most occurred prior to 2013. Use of 2013 as the reference year does not consider the higher value of the earlier sales figures. For example, a dollar in 2013 was worth 35.3 percent less than a dollar in 2000, and 15.6 percent less than a dollar in 2005.[17]

For all of the above reasons, the total sales figures reported in this survey are conservative and substantially understate the actual total sales resulting from Air Force SBIR/STTR Phase II contracts completed during the FY 2000-2013 period.

[16] *D.R. Stewart and J.A. Byrd, "The Significance of Underreported Royalties-2007 Update: The Magnitude and Meaning of Royalty Misreporting," Invotex Group, Baltimore, MD, February 2007, online at: www.lawseminars.com/materials/07LICIL/licil%20m%20stewart2.pdf; D.R. Stewart and J.A. Byrd, "89% of Royalty Revenue is Underreported! Top Five Questions You Should Ask Your Licensee to Avoid Becoming a Statistic," Invotex Group, Baltimore, MD, April 2012, online at: www.invotex.com/assets/2012_Royalty_Audit_Article.pdf.*

[17] *U.S. Bureau of Labor Statistics Consumer Price Index (CPI) Inflation Calculator, available online at http://www.bls.gov/data/inflation_calculator.htm*

Commercialization Success was Inversely Related to the Number of Awards

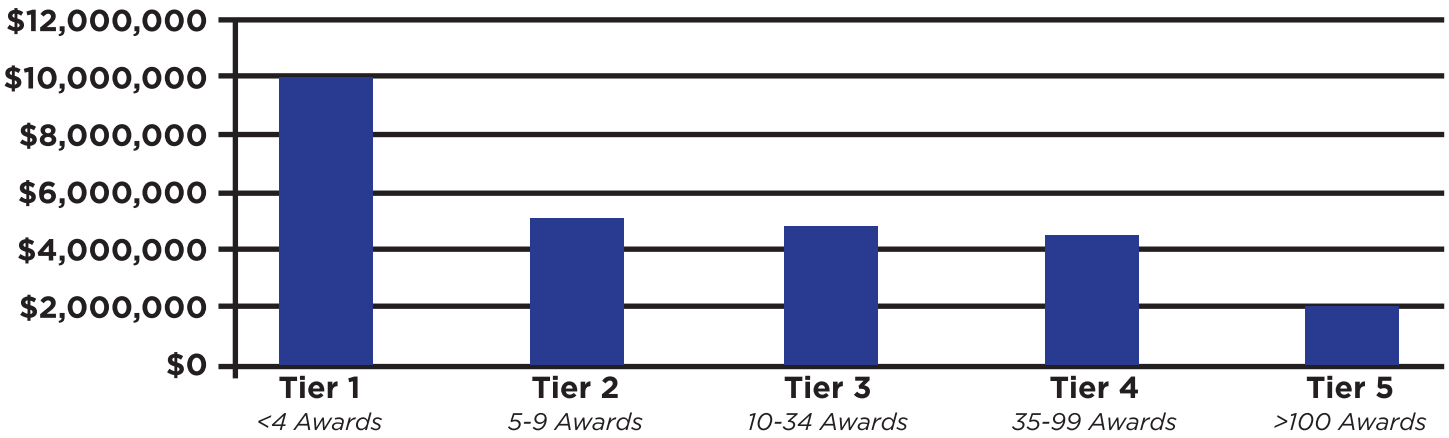
One of the study's surprising discoveries is that the commercialization success of the companies receiving Air Force SBIR/STTR Phase II contracts is on average inversely related to the total number of SBIR/STTR awards (Phase I and II) received by those companies from any federal agency. That is, the more SBIR funding they received, the less successful they were at converting that funding into new products and services that achieved commercial sales and/or supported the U.S. defense mission. This finding runs counter to the common wisdom in many SBIR circles, which is that the "most successful" companies are those that secure the most SBIR awards.

For purposes of analysis, the companies in the study were divided into tiers, based on the total number of Phase I and Phase II SBIR/STTR awards that they had received from the U.S. government, regardless of the federal agency:

- **Tier 1 companies:** 4 or fewer total awards
- **Tier 2 companies:** 5 to 9 awards
- **Tier 3 companies:** 10 to 34 awards
- **Tier 4 companies:** 35 to 99 awards
- **Tier 5 companies:** 100 or more total SBIR/STTR awards.

Tier 1 companies were generally the most successful at commercializing technologies developed with Air Force SBIR/STTR Phase II funding, and Tier 5 companies were, on the whole, the least successful. Table 4 shows the strong inverse relationship between the number of awards and commercialization success.

Table 4. Sales from Air Force SBIR/STTR Phase II Contracts Related to Number of Awards



This table shows that Tier 1 companies, with 4 or fewer total SBIR/STTR awards, achieved sales averaging nearly $10 million ($9,941,387) from each Air Force SBIR/STTR contract that achieved sales. This was five times the average of slightly less than $2 million ($1,978,740) in sales achieved by Tier 5 companies, which had each received 100 or more awards. It was also twice the average achieved by Tier 2 companies ($5,021,508). Average sales for Tier 3 companies were $4,517,090, followed by $4,516,062 for Tier 4 companies. As earlier noted, the average for all companies with sales was $5.6 million. This means that the Tier 1 companies were so successful, they raised the average of all contracts in the survey above that achieved in any of the other tiers.

Tier 1 companies accounted for four out of five of the most successful Air Force SBIR/STTR Phase II contracts (the other was a Tier 4 contract). Of the 23 contracts that achieved sales of $100 million or more, Tier 1 accounted for ten contracts, Tier 2 for four, Tier 3 for six, Tier 4 for two, and Tier 5 for one.

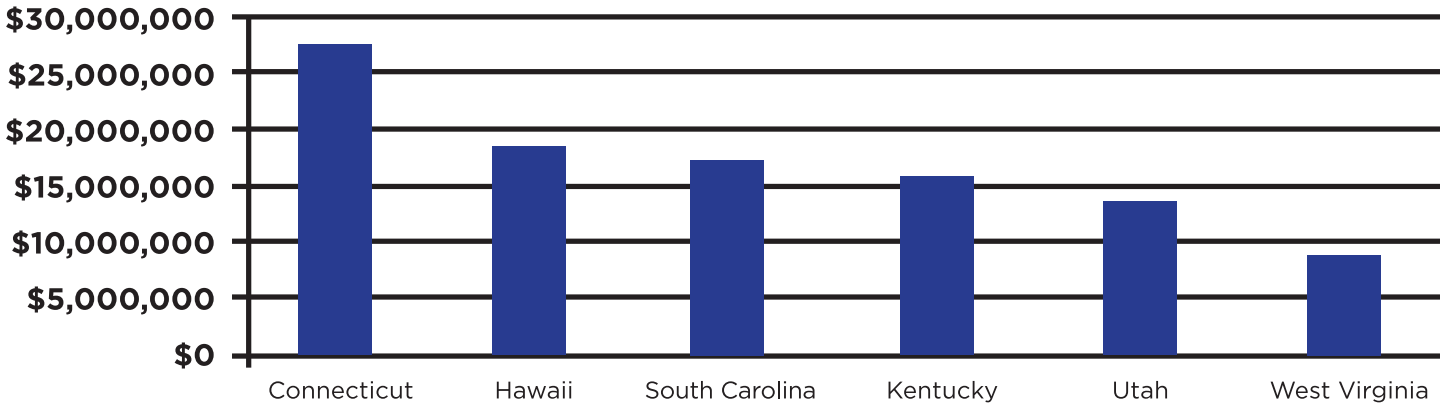
Underserved States Were More Successful at Commercialization, but Received Substantially Fewer Awards

Another surprising discovery is that, on average, the companies that were most successful at commercializing technologies developed with Air Force SBIR/STTR Phase II funding were located in states classified by the SBA as "underserved," as measured by the number of total SBIR/STTR awards received. The SBA considers 27 states and territories (subsequently referred to as "states") to be underserved: Alaska, Arkansas, District of Columbia, Delaware, Hawaii, Iowa, Idaho, Kansas, Kentucky, Louisiana, Maine, Missouri, Mississippi, Montana, North Dakota, Nebraska, Nevada, Oklahoma, Puerto Rico, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Vermont, West Virginia, and Wyoming.[18]

The present study found that, on average, companies in the SBA underserved states significantly outperformed companies in the other states in commercialization success. Their average sales amount per contract (among contracts generating sales) was $6.6 million, compared to $5.5 million for companies in other states. For all contracts, the sales per contract in SBA underserved states averaged $4.1 million, versus $3.2 million for the other states. Moreover, companies in underserved states achieved sales with 63 percent of their Air Force Phase II contracts, compared to 55 percent for companies in the other states.

Impressively, the SBA underserved states accounted for 5 of the "Top 6" states for average commercialization success (see Table 5). These underserved states were Hawaii, South Carolina, Kentucky, Utah, and West Virginia. Connecticut was the only non-underserved state in this top-performing group. Phase II contract recipients in Hawaii achieved average sales of $19.1 million from their Air Force SBIR/STTR innovations—well over three times the national average for contracts with sales and six times the average for all contracts. Companies in the other SBA underserved states in this top group had sales that were roughly 3 to 5 times the average for all contracts.

Table 5. The "Top 6" States for Average Sales Resulting from Air Force SBIR/STTR Phase II Contracts



[18] *SBIR/STTR Outreach, The Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR) Program Interagency Policy Committee Report to Congress, Office of Science and Technology, Small Business Administration, September 15, 2014*

Despite the greater commercialization success of companies in the underserved states, the 27 SBA underserved states received only 6 percent of the Air Force SBIR/STTR Phase II awards in this study.[19] The remainder of the awards went to the other states. In fact, slightly over half (50.1 percent) of all Air Force Phase II awards in the study were concentrated in just four states: California, Massachusetts, Ohio, and Colorado. (See Appendix 2 for a breakout of the Air Force SBIR/STTR Phase II awards by state.)

The small 6-percent number of awards to SBA underserved states, found in this study, is similar to the percentage of awards to SBA underserved states from all federal SBIR/STTR programs: 8.2 percent of all awards (Phases I and II) during the period from 1983 to 2014.[20] Because the SBA underserved states have a much smaller population, this lower award level might initially seem appropriate. However, the underserved states do constitute a fifth of the total U.S. population (21 percent per 2010 census figures), a significantly higher percentage than the SBIR/STTR award levels. When normalized for population, companies in the underserved states received only 24 percent of the total Air Force SBIR/STTR Phase II awards.[21]

This is the first study able to quantify the commercialization success of companies in SBA underserved states versus companies in the rest of the United States. The disconnect between the significantly greater commercialization success of companies in the SBA underserved states and the substantially lower number of Phase II awards warrants further investigation and indicates an area for possible targeted intervention.

Other Economic Outcomes and Impacts

In addition to sales, the companies in the study reported other significant economic outcomes and impacts. The total outside investment funding (including venture capital and angel funding) directly related to the innovations developed with Air Force SBIR/STTR Phase II contracts was reported to be approximately $1.9 billion. The number of companies that were acquired primarily because of the technology developed with Air Force SBIR/STTR funding was **225**, with a total acquisition value reported to be around $6.8 billion. However, this figure certainly understates the actual value. A large majority of acquired companies stated that the terms of acquisition prevented them from disclosing the acquisition amount. Finally, companies in the study reported that they had licensed 180 technologies to other companies, and that they had created a total of 125 spin-out companies specifically to commercialize 147 of the technologies developed with Air Force SBIR/STTR Phase II funding. These other economic outcomes and impacts are summarized below:

- **Total outside investment funding:**
  $1,872,054,662
- **Number of companies that were acquired:**
  225
- **Total acquisition value of companies acquired:**
  $6,768,331,783
- **Number of technologies licensed to other companies:**
  180
- **Number of spin-out companies created:**
  125
- **Number of technologies being commercialized by spin-outs**
  147

[19] *Per the Air Force SBIR/STTR awards database, the SBA underserved states received 267 Phase II contracts out of a total of 4,524 contracts included in the study period.*
[20] *Per the Small Business Administration SBIR/STTR Awards database at the time of this analysis, underserved states received a total of 11,970 SBIR/STTR awards, out of a total of 146,434 awards nationally. See www.sbir.gov/past-awards.*
[21] *Companies in SBA underserved states completed 4.1 Air Force SBIR/STTR Phase II contracts per one million residents during the FY 2000-2013 study period, versus 17.2 contracts per one million residents for the other U.S. states.*

Economic Impact Analysis

Upon receiving the company sales and six-digit NAICS code data from TechLink, the Business Research Division (BRD) at the Leeds School of Business, University of Colorado Boulder, used the national IMPLAN input-output model to determine the economic impacts of the Air Force SBIR/STTR Phase II contracts completed during the study period, FY 2000-2013. This was undertaken in two stages: (1) IMPLAN analysis of the economic impacts resulting from the nearly $4 billion in Phase II R&D activity; and (2) IMPLAN analysis of the sales of the innovations resulting from this R&D. Results below are presented for output, employment, labor income, and value added. As previously noted, all dollar figures are reported in 2013 dollars.

Output

Output is the total value of all goods or services (including intermediate goods and services) produced during a given time period, whether used for further production or consumed. The concept of national output is an integral part of macroeconomics. Output is closely associated with economic-impact analysis and is one of the values most frequently cited following the completion of economic-impact studies.

Air Force SBIR/STTR Phase II R&D Activity.
According to the national IMPLAN model, the nearly $4 billion (2013 $) in Air Force SBIR/STTR Phase II R&D contracts provided to small businesses throughout the United States generated a total of $10.51 billion in economic output nationwide. Of this amount, around $2.85 billion was generated indirectly as the result of inter-industry purchases (firms purchasing from each other), and $3.67 billion was generated from the induced effect, the result of households spending payroll on goods and services economy-wide (see Table 6).

Dividing the economy-wide output ($10.51 billion) by the direct value of the Air Force SBIR/STTR Phase II contracts ($3.99 billion) yields an output multiplier of 2.64. That is, for every dollar in economic activity directly attributable to the Air Force SBIR/STTR Phase II R&D, an additional $1.64 in economic activity was generated nationwide.

Table 6: Economic Impact of Air Force SBIR/STTR Phase II R&D Activity, FY 2000-2013

IMPACT TYPE	Employment *Job Years*	Employment *Av. per year*	Labor Income *In Billions*	Labor Income *Per Job*	Value Added *In Billions*	Output *In Billions*
Direct Effect	17,978	1,284	$1.64	$91,045	$2.07	$3.99
Indirect Effect	17,806	1,272	$1.06	$59,609	$1.78	$2.85
Induced Effect	23,931	1,709	$1.15	$48,163	$2.03	$3.67
Total Effect	**59,715**	**4,265**	**$3.85**	**$64,486**	**$5.88**	**$10.51**

Sales of Air Force SBIR/STTR Phase II innovations

In addition to the economic output from Phase II R&D, this study examined the output from the subsequent sales of the innovations resulting from this R&D. According to the national IMPLAN model, the $14.7 billion (2013 $) in direct sales of new products and services reported by companies generated an additional $22.7 billion in sales economy-wide. Of this amount, around $11.6 billion was generated indirectly as the result of inter-industry purchases, and $11.1 billion was generated from households spending payroll on goods and services (the induced effect). The total economy-wide output from sales of the Air Force SBIR/STTR Phase II-developed technology was $37.4 billion (see Table 7).

Dividing total economy-wide output ($37.4 billion) by the direct output of companies selling products and services related to their Air Force SBIR/STTR Phase II contracts yields an output multiplier of 2.55. For every dollar in sales directly attributable to the Air Force SBIR/STTR Phase II contracts, an additional $1.55 in sales was generated economy-wide.

Table 7: Economic Impact of Subsequent Company Sales, FY 2000-2013

IMPACT TYPE	Employment *Job Years*	Employment *Av. per year*	Labor Income *In Billions*	Labor Income *Per Job*	Value Added *In Billions*	Output *In Billions*
Direct Effect	47,359	3,383	$4.55	$96,152	$6.79	$14.69
Indirect Effect	55,312	3,951	$3.59	$64,933	$5.95	$11.60
Induced Effect	72,124	5,152	$3.47	$48,169	$6.11	$11.07
Total Effect	**174,795**	**12,485**	**$11.62**	**$66,474**	**$18.85**	**$37.36**

Value Added

Value added is the difference between an industry's or company's output and the cost of intermediate inputs. Expressed differently, it is the difference between a product's sale price and its production cost. This measure recognizes that companies buy goods and services from other companies in order to create products of greater value than the sum of the goods and services used to make these products. This increase in value resulting from the production process is the "value added." As estimated by IMPLAN, value added is equal to the total sales (plus or minus inventory adjustments) minus the cost of the goods and services purchased to produce the products sold.

The main difference between output and value added is that output includes the value of intermediate goods and services, while value added does not. Many economists prefer value added as an economic measure because, at the macroeconomic scale, output multiple-counts the value of inputs. For example, in the previously cited case of Company X, which sells an eye surgery laser device developed with its Air Force SBIR/STTR Phase II contract: Company X purchases laser rods, electronic components, optical components, and various raw materials to make the device. The value of Company X's sales incorporates the value of these laser rods and other inputs. Further, each of the companies from which Company X purchases its inputs incorporates the value of their respective inputs from other companies. By combining and aggregating the values of intermediate and final products, output overstates the size of the US economy by a factor of roughly 2. For this reason, Gross Domestic Product (GDP), a measure of value added, is used to track the size of the U.S. economy because it is a non-duplicative aggregation of production across all industries in the United States. In the current study, value added measures the real contribution that the Air Force SBIR/STTR Phase II contract recipients made to the national economy as a result of receiving that funding.

Air Force SBIR/STTR Phase II R&D Activity

According to the national IMPLAN model, the initial nearly $4 billion in R&D contracts (2013 $) generated an additional $5.88 billion in value added impact economy-wide. Of this total, $2.07 billion was generated directly, $1.78 billion was generated indirectly, and $2.03 billion was generated from the induced effect (see Table 6).

Sales of Air Force SBIR/STTR Phase II innovations

Subsequent IMPLAN analysis showed that the $14.7 billion (2013 $) in sales reported by companies generated $18.85 billion in value added impact economy-wide: $6.8 billion generated directly, $5.9 billion indirectly, and $6.1 billion from the induced effect (see Table 7).

Employment

Employment in this analysis refers to the number of jobs created or sustained by an economic activity. It is a measure of the number of workers (either full-time or full-time equivalent, if part-time) expressed in "job years" (one full-time position for a year).

Air Force SBIR/STTR Phase II R&D Activity

The national IMPLAN model estimated that 17,978 jobs were directly sustained economy-wide by the nearly $4 billion in Phase II R&D activity. Indirect effects were responsible for an additional 17,806 jobs, and induced effects for 23,931 jobs. The IMPLAN model estimates that, altogether, 59,715 jobs nationwide resulted from the direct, indirect, and induced effects of the Air Force SBIR/STTR Phase II R&D activity (see Table 6).

Sales of Air Force SBIR/STTR Phase II innovations

According to the national IMPLAN model, the $14.7 billion in sales directly sustained an estimated 47,359 jobs economy-wide. Indirect effects were responsible for an additional 55,312 jobs, and induced effects for 72,124 jobs. The IMPLAN model estimates that, altogether, 174,795 jobs nationwide resulted from the direct, indirect, and induced effects of the sales of Air Force SBIR/STTR Phase II innovations (see Table 7).

SEEDING SUCCESS

Lifesaving Emergency Medical Device

An Air Force combat medical technician simulates inserting an intraosseous device in a casualty during a joint tactical exercise designed to provide realistic military training in an urban setting. *(U.S. Air Force photo by Airman 1st Class Jasmonet Jackson)*

In emergency medicine, many patients urgently need intravenous (IV) infusion at the very moment that their veins are inaccessible to traditional IV needles. Severe shock from injury or heart failure causes peripheral veins to collapse.

In 2006, San Antonio-based Vidacare received Air Force SBIR/STTR Program funding, which led to development of the EZ-IO Intraosseous Infusion System used today. EZ-IO provides a rapid, near-foolproof way of getting blood, rehydration fluids, or medicine into a patient's circulation system by injecting these fluids into bone marrow, a process that is nearly painless.

The device, battery-operated and about the size of a glue gun, is lifesaving in cases of cardiac arrest, major trauma, shock, sepsis, and extreme dehydration. EZ-IO has an impressive 97 percent success rate, much higher than achieved with standard IVs.

To date, roughly 3 million EZ-IO units have been purchased in over 50 countries, with many more provided gratis for humanitarian relief efforts, resulting in tens of thousands of lives saved. In the U.S., an EZ-IO kit is carried in 95 percent of all ambulances and about 85 percent of emergency departments. The EZ-IO system is also widely used by the U.S. military. In 2013, Vidacare was acquired by Teleflex, a global provider of medical devices used in critical care and surgery.

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Labor Income

Labor income consists of employee compensation (wage and salary payments, including benefits), paid to workers as well as proprietary income (income received by self-employed individuals).

Air Force SBIR/STTR Phase II R&D Activity

The national IMPLAN model estimated that labor income directly associated with the nearly $4 billion in Phase II R&D activity was $1.64 billion in 2013, or approximately $91,045 per job (see Table 6). This was 83 percent higher than the average annual pay in the U.S. in 2013 of $49,808.[22] The indirect labor income was estimated at $1.06 billion, or approximately $59,609 per job. The induced labor income was estimated to be $1.15 billion, or $48,163 per job. Average wages for the indirect and induced jobs were substantially lower than the average wage for the jobs directly created or retained because many of these jobs were in lower-paid manufacturing and service sectors. Together, the indirect and induced labor income amounted to $2.21 billion. The total economy-wide labor income resulting in 2013 from the Air Force SBIR/STTR Phase II R&D activity was $3.85 billion. The average wage of the approximately 59,715 jobs created or retained as a result of the Air Force SBIR/STTR Phase II activity was $64,486, approximately 29 percent higher than the average U.S. wage of $49,808 in 2013.

Sales of Air Force SBIR/STTR Phase II innovations

According to the national IMPLAN model, the labor income directly associated with the $14.7 billion in sales reported by companies was $4.6 billion in 2013, or approximately $96,152 per job (see Table 7). This was nearly twice the average U.S. wage in 2013. The indirect labor income was estimated at $3.6 billion, or approximately $64,933 per job. The induced labor income was estimated to be $3.5 billion, or $48,169 per job. The total economy-wide labor income resulting in 2013 from sales of the Air Force SBIR/STTR Phase II innovations was $11.6 billion. The average wage of the approximately 174,795 jobs created or retained as a result of the Air Force SBIR/STTR Phase II contracts was $66,474, approximately 33 percent higher than the average U.S. wage of $49,808 in 2013.

[22] *Bureau of Labor Statistics, Quarterly Census of Employment and Wages, www.bls.gov.*

Tax Revenue

Tax revenues were estimated for the nearly $4 billion in Air Force Phase II R&D activity and $14.7 billion in subsequent sales, including their associated economy-wide indirect and induced effects. These tax revenues included social insurance taxes (paid by employers, employees, and the self-employed), personal income taxes, motor vehicle licenses, property taxes, corporate profits taxes and dividends, and indirect business taxes (comprised mainly of excise and property taxes, fees, licenses, and sales taxes). Total taxes collected by federal, state, and local government entities were estimated at $3.9 billion. This included $1.25 billion in tax revenues on direct sales, $1.24 billion on indirect sales, and $1.41 billion on induced sales (see Table 8).

SUMMARY

NEARLY

$48B

In Economic Impact

In summary, this study estimated the economic contribution to the U.S. economy of Air Force SBIR/STTR Phase II contracts completed during the FY 2000-2013 period. Its purpose was to determine the extent to which these contracts both contributed to new economic activity and job creation in the United States, and resulted in the transition of new technology to U.S. military use.

The research team contacted 1,750 companies that completed SBIR/STTR Phase II contracts from the Air Force during the FY 2000-2013 period. A total of 4,524 Phase II contracts were included in the study because some companies had multiple contracts. Companies were asked to divulge the total sales of new products and services directly related to their Air Force SBIR/STTR Phase II contracts. They were also asked about their related sales to the U.S. military (either directly or through a defense contractor) as well as follow-on R&D contracts, licensing revenue, and sales by licensees and spin-out companies.

Companies reported that 58 percent of their Air Force Phase II contracts—2,631 out of 4,524—resulted in sales. Collectively, they reported approximately $14.7 billion in total sales and nearly $4.4 billion in military product sales (in 2013 dollars). Other significant economic outcomes directly related to the innovations developed with Air Force SBIR/STTR Phase II funding included outside investment funding of around $1.9 billion, 225 company acquisitions with a total acquisition value of well over $6.8 billion (the majority of companies were unable to disclose the acquisition terms), 180 technologies licensed to other companies, and a total of 125 new spin-out companies.

IMPLAN economic-impact assessment software was used to estimate the total economic impacts related to both the Air Force SBIR/STTR Phase II R&D activity and subsequent sales of new technologies developed with this R&D. Impacts analyzed included economic output, value added, employment, and labor income. Total economy-wide sales, as measured by output, were estimated at $47.87 billion. Value added was estimated at $24.73 billion, representing new wealth creation in the economy. Labor income in 2013 was estimated at $15.47 billion. Employment impacts included 234,511 total job years, or an average of 16,751 jobs per year, with an average wage of approximately $65,968. Table 8 summarizes the total economic contribution of the Air Force SBIR/STTR Program.

Table 8. Nationwide Economic Impacts from Air Force SBIR/STTR Phase II Contracts, FY 2000-2013

IMPACT TYPE	Employment *Job Years*	Employment *Av. per year*	Labor Income *In Billions*	Labor Income *Per Job*	Value Added *In Billions*	Output *In Billions*
Direct Effect	65,337	4,667	$6.19	$94,747	$8.86	$18.68
Indirect Effect	73,118	5,223	$4.65	$63,636	$7.72	$14.44
Induced Effect	96,056	6,861	$4.63	$48,167	$8.14	$14.74
Total Effect	**234,511**	**16,751**	**$15.47**	**$65,968**	**$24.73**	**$47.87**

Source: Business Research Division, Leeds School of Business, University of Colorado, Boulder; 2013 IMPLAN National Model
Note: Totals may not tally due to rounding

SEEDING SUCCESS

Rapid Disease Detection

Ebola virus particles are shown in blue as the particles bud from an infected cell, shown in yellow. (National Institute of Allergy and Infectious Diseases). *Previously released at directorsblog.nih.gov without a copyright restriction.*

Identifying infectious diseases in the field is difficult. Rarely is a fully stocked testing laboratory nearby. Yet, the timely detection of diseases such as Ebola is essential in order to contain outbreaks and provide much-needed treatment.

Biofire Diagnostics, based in Salt Lake City, Utah, received Air Force SBIR funding in 2002 (under its previous name, Idaho Technology), to develop a major breakthrough in disease diagnostics with its automated FilmArray System — a lab-in-a-box about the size of a toaster. Instead of requiring liquid chemicals, each test packet contains reagents in room-temperature-stable, freeze-dried form. It requires only two minutes of hands-on setup, then automatically provides results in an hour.

The FilmArray is the only system that completely integrates all the processes required to analyze a patient sample. It simultaneously identifies multiple disease pathogens, including bacteria, fungi, viruses, and parasites. The FilmArray biothreat panel, for example, identifies anthrax, Ebola, plague, botulism, and thirteen other deadly pathogens. There are separate respiratory, gastrointestinal, and blood culture panels for identifying more common diseases.

The FilmArray was recently deployed by the U.S. military in Africa as an Ebola screening tool, and has now been adopted by the U.S. government and over 300 major hospitals because of its ease of use and rapid results. In January 2014, multinational biotechnology company BioMérieux acquired BioFire, enabling greatly expanded international use of this life-saving technology.

Appendix 1: NAICS Codes Assigned to Companies in the Study

NAICS	DESCRIPTION
321213	Engineered wood member (except truss) manufacturing
322299	Epitaxial Technologies for SiGeSn High Performance Optoelectronic Devices
325130	Synthetic dye and pigment manufacturing
325180	Other basic inorganic chemical manufacturing
325199	All other basic organic chemical manufacturing
325211	Plastic material and resin manufacturing
325412	Pharmaceutical preparation manufacturing
325413	In-vitro diagnostic substance manufacturing
325510	Paint and coating manufacturing
325520	Adhesive manufacturing
325613	Surface active agent manufacturing
325998	All other miscellaneous chemical product and preparation manufacturing
326150	Urethane and other foam product (except polystyrene), manufacturing
326199	All other plastic product manufacturing

NAICS	DESCRIPTION
327999	All other miscellaneous nonmetallic mineral product manufacturing
331313	Alumina refining and primary aluminum production
331513	Steel foundries (except investment)
331524	Aluminum foundries (except die-casting)
331529	Other nonferrous metal foundries (except die-casting)
332216	Saw blade and handtool manufacturing
332313	Plate work manufacturing
332410	Power boiler and heat exchanger manufacturing
332510	Hardware manufacturing
332811	Metal heat treating
332812	Metal coating, engraving (except jewelry and silverware), and allied services to manufacturers
332813	Electroplating, plating, polishing, anodizing, and coloring
332991	Ball and roller bearing manufacturing
332993	Ammunition (except small arms) manufacturing
332999	All other miscellaneous fabricated metal product manufacturing
333242	Semiconductor machinery manufacturing
333249	Other industrial machinery manufacturing
333314	Optical instrument and lens manufacturing
333316	Photographic and photocopying equipment manufacturing
333318	Other commercial and service industry machinery manufacturing
333414	Heating equipment (except warm air furnaces) manufacturing
333415	Air-conditioning and warm air heating equipment and commercial and industrial refrigeration manufacturing
333514	Special die and tool, die set, jig, and fixture manufacturing
333515	Cutting tool and machine tool accessory manufacturing
333517	Machine tool manufacturing
333612	Speed changer, industrial high-speed drive, and gear manufacturing
334111	Electronic computer manufacturing
334118	Computer terminal and other computer peripheral equipment manufacturing
334210	Telephone apparatus manufacturing
334220	Radio and television broadcasting and wireless communications equipment manufacturing
334290	Other communications equipment manufacturing
334413	Semiconductor and related device manufacturing
334417	Electronic connector manufacturing
334418	Printed circuit assembly (electronic assembly) manufacturing
334419	Other electronic component manufacturing
334510	Electromedical and electrotherapeutic apparatus manufacturing
334511	Search, detection, navigation, guidance, aeronautical, and nautical system and instrument manufacturing
334513	Instruments and related products manufacturing for measuring, displaying, and controlling industrial processes
334515	Instrument manufacturing for measuring and testing electricity and electrical signals
334516	Analytical laboratory instrument manufacturing
334519	Other measuring and controlling device manufacturing
335311	Power, distribution, and specialty transformer manufacturing
335312	Motor and generator manufacturing
335911	Storage battery manufacturing
335912	Primary battery manufacturing
335921	Fiber optic cable manufacturing
335991	Carbon and graphite product manufacturing
335999	All other miscellaneous electrical equipment and component manufacturing

NAICS	DESCRIPTION
336310	Motor vehicle gasoline engine and engine parts manufacturing
336390	Other motor vehicle parts manufacturing
336411	Aircraft manufacturing
336412	Aircraft engine and engine parts manufacturing
336413	Other aircraft parts and auxiliary equipment manufacturing
336414	Guided missile and space vehicle manufacturing
336415	Guided missile and space vehicle propulsion unit and propulsion unit parts manufacturing
336419	Other guided missile and space vehicle parts and auxiliary equipment manufacturing
336992	Military armored vehicle, tank, and tank component manufacturing
339112	Surgical and medical equipment manufacturing
339113	Surgical appliance and supplies manufacturing
339115	Ophthalmic goods manufacturing
339920	Sporting and athletic goods manufacturing
339991	Gasket, packing, and sealing device manufacturing
339999	All other miscellaneous manufacturing
488190	Other support activities for air transportation
511210	Software publishers
518210	Data processing, hosting, and related services
541330	Engineering services
541360	Geophysical surveying and mapping services
541380	Testing laboratories
541420	Industrial design services
541511	Custom computer programming services
541512	Computer systems design services
541690	Other scientific and technical consulting services
541711	Research and development in biotechnology
541712	Research and development in the physical, engineering, and life sciences (except biotechnology)
541720	Research and development in the social sciences and humanities
562910	Remediation services
611420	Computer training
611430	Professional and management development training
611512	Flight training

Appendix 2: Air Force SBIR/STTR Phase II Contracts by State

RANK	STATE	FUNDING ($)	PERCENTAGE	CUMULATIVE %
1	CA	906,570,759	22.7%	22.7%
2	MA	544,719,047	13.6%	36.3%
3	OH	328,784,535	8.2%	44.6%
4	CO	242,960,183	6.1%	50.7%
5	VA	240,551,992	6.0%	56.7%

RANK	STATE	FUNDING ($)	PERCENTAGE	CUMULATIVE %
6	TX	187,709,126	4.7%	61.4%
7	NY	157,582,090	3.9%	65.3%
8	FL	133,396,253	3.3%	68.7%
9	MD	124,115,872	3.1%	71.8%
10	PA	113,214,010	2.8%	74.6%
11	AL	97,161,337	2.4%	77.1%
12	NM	95,310,144	2.4%	79.5%
13	MI	82,991,175	2.1%	81.5%
14	WA	71,908,964	1.8%	83.3%
15	NJ	66,685,817	1.7%	85.0%
16	AZ	64,370,391	1.6%	86.6%
17	NH	57,203,370	1.4%	88.1%
18	IL	54,983,305	1.4%	89.4%
19	CT	45,075,691	1.1%	90.6%
20	UT*	43,226,848	1.1%	91.6%
21	GA	39,036,526	1.0%	92.6%
22	MN	31,751,265	0.8%	93.4%
23	NC	28,924,988	0.7%	94.1%
24	TN	22,756,826	0.6%	94.7%
25	IN	21,807,461	0.5%	95.3%
26	NV*	17,130,673	0.4%	95.7%
27	OK*	16,199,976	0.4%	96.1%
28	WI	15,051,566	0.4%	96.5%
29	MO*	14,575,533	0.4%	96.8%
30	OR	13,588,463	0.3%	97.2%
31	WV*	12,088,678	0.3%	97.5%
32	AR*	10,969,698	0.3%	97.8%
33	VT*	9,974,314	0.2%	98.0%
34	MT*	9,820,486	0.2%	98.2%
35	NE*	8,344,970	0.2%	98.5%
36	DE*	7,383,765	0.2%	98.6%
37	SC*	6,728,803	0.2%	98.8%
38	RI*	5,967,819	0.1%	99.0%
39	ID*	5,674,449	0.1%	99.1%
40	ME*	5,512,081	0.1%	99.2%
41	HI*	4,566,603	0.1%	99.4%
42	WY*	4,481,838	0.1%	99.5%
43	MS*	4,249,615	0.1%	99.6%
44	LA*	3,680,198	0.1%	99.7%
45	DC*	2,788,897	0.1%	99.7%
46	ND*	2,748,268	0.1%	99.8%
47	IA*	2,499,231	0.1%	99.9%
48	KS*	2,221,606	0.1%	99.9%
49	KY*	1,499,975	0.0%	**100.0%**
TOTAL:		**$3,990,545,480**	**100%**	

** Underserved states. Note: AK, PR, and SD are also listed as underserved but received no Air Force Phase II contracts during the study period.*

About SBIR/STTR

The Small Business Innovation Research program was established by Congress in 1982 to fund research and development (R&D) by small businesses of 500 or fewer employees. Eleven federal agencies participate in the program, including the Department of Defense.

The Small Business Technology Transfer program was established in 1992 to fund cooperative R&D projects with small businesses and non-profit U.S. research institutions, such as universities. Five federal agencies participate, including the Department of Defense.

Both programs focus on projects and services with the potential to develop into a product for military or commercial sectors.

BUDGET

SBIR
$284 MIL For Air Force

STTR
$39 MIL For Air Force

The Air Force Is Both An Investor & A Customer

- **Focused on the WARFIGHTER**
- **About 160 topics per year**
- **Company retains data rights for 5 years**
- **Sole sourcing allowed for follow-on awards**
- **25% of awardees are first-time selectees**

SEEDING SUCCESS

Rapid Electric Charging Stations

A fleet of plug-in electric vehicles sits ready to roll at Los Angeles Air Force Base, California. *(U.S. Air Force photo by Technical Sgt. Sarah Corrice)*

Large amounts of fuel are consumed in airports by ground support vehicles. Although many airports have electric vehicles, most require exchanging the battery packs, which takes time and requires a dedicated space.

AeroVironment, a pioneer in electric vehicles based in Monrovia, California, addressed this problem with Air Force SBIR funding by developing the PosiCharge® rapid battery charging system. The system allows multiple battery packs to be charged in a station in as little as ten minutes. Batteries are recharged in-vehicle when operators take breaks and between shifts, allowing vehicle operation 24 hours a day every day.

PosiCharge now powers over 3,500 vehicles in the nation's airports and more than 10,000 vehicles in factories and distribution centers. Seattle-Tacoma International Airport, for example, is installing 576 PosiCharge system ports and plans to convert all its ground support vehicles to electric, saving up to $3 million in energy costs and reducing its carbon footprint by 10,000 metric tons a year.

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(Photo: U.S. Air Force photo/Senior Airman Debbie Lockhart)


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National Economic Impacts from the Navy SBIR/STTR Program, 2000-2013

EXECUTIVE SUMMARY

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are the U.S. government's primary way of encouraging and supporting research and development (R&D) in the nation's technology-focused small business community. The Navy accounts for approximately 12 percent of all federal SBIR/STTR funds.

This study quantifies the Navy SBIR/STTR Program's overall contribution to the nation's economy and defense mission. It examines the economic outcomes and impacts from all Navy SBIR/STTR Phase II awards completed during the fiscal year (FY) 2000-2013 period, providing definitive answers to the question: *What resulted from the Navy's SBIR/STTR investment of nearly $2.3 billion, provided to companies nationwide in 2,734 separate SBIR/STTR contracts?*

The study was conducted by TechLink, a DoD-funded technology transfer center at Montana State University-Bozeman, in collaboration with the Bureau Research Division (BRD) of the Leeds School of Business at the University of Colorado in Boulder. The research team contacted all 1,199 companies that completed Navy SBIR/STTR Phase II contracts during the study period. Companies were asked to divulge the total sales of new products and services directly related to their Navy SBIR/STTR Phase II contracts. They also were asked about related economic outcomes, including sales to the U.S. military, follow-on R&D contracts, licensing revenue, and sales by licensees and spin-out companies. The team was able to obtain full or partial information on the economic outcomes of 2,598 contracts out of the 2,734 total, for an effective response rate of 95 percent.

Well over half of the Navy Phase II contracts—64 percent—resulted in sales of new products and services based on the innovations developed under these contracts. IMPLAN economic-impact assessment software was used to estimate the economic impacts resulting from the sales and other economic outcomes. Study results are believed to significantly understate the actual economic impacts because of non-responding companies, the effects of inflation, and other factors analyzed in the report. *Major findings include the following:*

- $14.2 billion in total sales of new products and services resulting from the Navy SBIR/STTR Phase II contracts
- $7 billion in sales of new products to the U.S. military
- $44.3 billion in total economic output nationwide
- $22.2 billion in value added, representing new wealth creation in the economy
- $4.9 billion in new tax revenues (federal, state, and local)
- $14.4 billion in labor income
- 14,973 full-time jobs created *per year* with an average salary of $68,535

PURPOSE OF STUDY

This study was undertaken to quantify the Navy SBIR/STTR Program's overall contribution to the national economy and nation's defense mission.[1] The study examined the economic outcomes and impacts from all Navy SBIR/STTR Phase II awards completed during the 2000-2013 period. It was intended to answer the following basic question: What resulted from the Navy's SBIR/STTR investment of nearly $2.3 billion, provided to 1,199 companies in 2,734 separate SBIR/STTR contracts?[2]

The study's primary objectives were (1) To determine the extent to which the Navy SBIR/STTR Program has contributed to new economic activity and job creation in the United States; and (2) to assess its effectiveness in generating new technology for Navy and other U.S. military use. The Navy SBIR/STTR Program commissioned the study.

THE NAVY SBIR/STTR PROGRAM IN CONTEXT

Federal SBIR programs date back to 1982 and were created to harness the innovative potential of U.S. small business—both to help meet the high-priority technology needs of the federal government and to benefit the national economy. Establishment of these programs was part of a larger effort in the United States during the early 1980s to make strategic government R&D investments to counter the loss of national economic competitiveness and related budget deficits.

In the enabling legislation, the Small Business Innovation Development Act of 1982,[3] Congress affirmed that technological innovation creates jobs and increases productivity, competitiveness, and economic growth. It also recognized that small businesses are the principal source of innovation in the United States and are generally more cost-effective in conducting R&D than major corporations, universities, and government laboratories. Finally, Congress asserted that, compared to these other entities, small businesses are more capable of converting R&D results into new products. However, it recognized that small businesses face greater difficulty securing funding for R&D and commercialization. Based on these findings, the Act was intended to (1) spur technological innovation in the United States; (2) help meet federal R&D needs; (3) increase private sector commercialization of innovations resulting from federally funded investments; and

[1] The federal Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are similar. However, STTR programs are much smaller and require small businesses to formally collaborate with not-for-profit research institutions, such as universities. See *www.sbir.gov*

[2] The exact amount of the Navy's SBIR/STTR Phase II investment was $2,261,502,616. Appendix 2 provides a breakdown of the Navy SBIR/STTR Phase II contracts by state.

[3] Text available at the following URL: *http://history.nih.gov/research/downloads/PL97-219.pdf*

(4) foster and encourage participation by minority and disadvantaged persons in technological innovation.

All federal agencies with extramural R&D budgets that exceed $100 million, currently 11 agencies, are required to allocate a small portion of their R&D budgets to SBIR. The designated amount is 3.0 percent in FY 2016 and 3.2 percent in FY 2017. In addition, the five federal agencies with extramural R&D budgets exceeding $1 billion (the Department of Defense, Department of Energy, Department of Health and Human Services, NASA, and National Science Foundation) are required to expend a much smaller percentage of their extramural R&D budgets for STTR. The designated amount is 0.45 percent in FYs 2016 and 2017.

Each agency determines its own R&D topics, issues solicitations, accepts proposals from small businesses (defined as for-profit entities with not more than 500 employees), establishes evaluation processes for these proposals, and makes awards on a competitive basis. The Small Business Administration (SBA) functions as the overall coordinating agency for both SBIR and STTR.

There are three phases to SBIR/STTR programs. *Phase I* funds short-term (typically six-month) feasibility studies of proposed innovations. These awards normally do not exceed $150,000. Assuming that a company establishes the scientific and technical merit as well as the commercial potential of its proposed innovation, it can compete for follow-on Phase II funding. *Phase II* funds the further development, testing and/or evaluation, such as by creation of a prototype, of the proposed innovation. Phase II awards normally do not exceed $1,000,000 and are typically for a two-year R&D effort. During *Phase III*, companies pursue commercialization (which can include transitioning to government acquisition programs) of technologies successfully developed during the previous two phases. No additional SBIR/STTR funding is available for this phase. However, some federal agencies provide supplemental, non-SBIR/STTR funding for further development of promising innovations to meet critical U.S. government technology needs.

Approximately $2.5 billion is awarded annually through the federal SBIR/STTR programs. The Department of Defense (DoD) is the largest participant, with approximately $1.07 billion in SBIR/STTR contracts annually. Within DoD, the Navy has the second largest individual program, after the Air Force. In FY 2015, it had a $289 million SBIR/STTR budget, versus $323 million for the Air Force. The Navy SBIR/STTR budget accounts for approximately 27 percent of the DoD total and nearly 12 percent of the entire federal SBIR/STTR budget.

IMPORTANCE OF STUDY

Given the large size of the Navy SBIR/STTR Program and the fact that it funds innovations in virtually all technology fields (including advanced materials, communications, electronics, energy and power, medical technologies, and software), this program provides an excellent case study of the economic outcomes

and impacts of the entire federal SBIR/STTR enterprise. These economic outcomes and impacts are important to understand. In fact, they are the key to determining how well the nation's major investments in SBIR and STTR are meeting their goals of spurring technological innovation, helping meet federal R&D needs, and increasing private-sector commercialization of innovations.

Surprisingly few studies have examined the actual economic outcomes and impacts of the federal SBIR/STTR programs. Most SBIR-related research has focused on issues such as the effectiveness of government programs in spurring innovation. NASA published a report in 2014 on the economic impact of its SBIR program.[4] However, that report only estimated the economic impacts of NASA SBIR funding provided to small businesses during a single year, FY 2012. It did not attempt to examine the subsequent economic impacts resulting from commercial sales of the innovations generated through this program.

Since the mid-2000s, the National Research Council (NRC) has been conducting an ambitious series of economic studies for Congress to assess the effectiveness of the overall SBIR initiative.[5] Those studies have focused on the SBIR programs of the five major funding agencies—Department of Defense, National Institutes of Health, NASA, the Department of Energy, and the National Science Foundation. In these studies, the NRC conducts surveys of statistical subsets of companies that have received SBIR funding and uses the survey findings to assess how well these agency programs have resulted in commercialization and contributed to the agencies' missions. However, the NRC studies do not attempt to assess the overall impacts of these agency programs, including how the SBIR/STTR-related R&D and subsequent sales of new products and services ripple through the national economy.

The major antecedent to the present study is a 2014 examination of the economic impacts of the Air Force SBIR/STTR Program, undertaken by the same team that conducted the present study.[6] That was the first-ever comprehensive analysis of the economic impacts of an entire federal SBIR/STTR program. In fact,

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[4] National Aeronautical and Space Administration, 2014, *SBIR/STTR Economic Impact Report, FY 2012,* Washington, DC: NASA.

[5] National Research Council, 2008, *An Assessment of the SBIR Program at the National Science Foundation*, Charles W. Wessner, ed. Washington, DC: The National Academies Press; National Research Council, 2008, *An Assessment of the SBIR Program at the Department of Energy*, Charles W. Wessner, ed. Washington, DC: The National Academies Press; National Research Council, 2009, *An Assessment of the SBIR Program at the National Institutes of Health*, Charles W. Wessner, ed. Washington, DC: The National Academies Press; National Research Council, 2009, *An Assessment of the SBIR Program at the Department of Defense*, Charles W. Wessner, ed. Washington, DC: The National Academies Press; National Research Council, 2009, *An Assessment of the SBIR Program at the National Aeronautics and Space Administration*, Charles W. Wessner, ed. Washington, DC: The National Academies Press. The first round of NRC studies is now being followed by a second round, starting with DoD: National Research Council, 2014, *SBIR at the Department of Defense*, Washington, DC: The National Academies Press.

[6] Available online at *http://static.techlinkcenter.org/techlinkcenter.org/files/economic-impacts/USAF%20SBIR-STTR%20Economic%20Impact%20Study%20FY2015.pdf*

the Air Force study served as the impetus for the Navy study and used essentially the same methodology. It surveyed all companies that had completed Air Force SBIR/STTR Phase II contracts during the 2000-2013 period, examining the economic outcomes and impacts resulting from those contracts.

Following the approach used in the Air Force study, the present study includes the national economic impacts resulting from both the Navy SBIR/STTR-funded R&D conducted by small businesses as well as from the sales of new products and services from the resulting innovations. It is a comprehensive study that addresses the overriding question: *What economic impacts resulted from the Navy's investment of nearly $2.3 billion in R&D projects completed by 1,199 small businesses during the FY 2000-2013 period?*

RESEARCH TEAM

As noted above, this economic-impact study was conducted by TechLink, a DoD-funded technology transfer center at Montana State University-Bozeman, in collaboration with the Bureau Research Division (BRD) of the Leeds School of Business at the University of Colorado in Boulder. Since 1999, TechLink has served as DoD's primary national "partnership intermediary," helping to develop technology transfer partnerships between DoD laboratories and U.S. industry nationwide. TechLink's primary focus is helping DoD labs transfer their inventions to U.S. companies through license agreements. TechLink currently brokers or facilitates approximately 60 percent of all DoD license agreements with industry. These license agreements enable companies to develop, manufacture, and sell products and services that incorporate DoD inventions. (For more information, see *www.techlinkcenter.org*)

The BRD has been analyzing local, state, and national economies for more than 95 years. It specializes in customized research and economic-impact studies that help companies, associations, nonprofits, and government agencies make informed business and policy decisions. The BRD has conducted economic-impact studies for a wide range of clients, including the National Renewable Energy Laboratory, Xcel Energy, Western Union, the American Petroleum Institute, and CO-LABS, a consortium of federally funded scientific laboratories, universities, businesses, and local governments in Colorado. (For more information, see *www.colorado.edu/leeds/centers/business-research-division*)

This is the seventh major economic-impact study undertaken by TechLink and the third study it has conducted with the BRD.[7] The principal authors were Dr. Will Swearingen and Ray Friesenhahn of TechLink and Brian Lewandowski and Dr. Richard Wobbekind of the BRD. Other key members of the TechLink team were Chris Huvaere, who created and managed the study's custom database; Phillip Luebke, Andrew Schoneberg, Christie Bell, John Verostek, and Audrey Wooding, who

[7] These studies are available online at *http://techlinkcenter.org/publications/economic-impacts*

contacted the companies in the survey to ask about their Phase II SBIR/STTR project results; and Kirkwood Donavin, who ensured the accuracy of the database entries and participated in analysis of the survey results.

METHODOLOGY

This study was undertaken in three major phases. First, during the *Data Gathering* phase, the research team contacted all companies that had completed Navy SBIR/STTR Phase II contracts during the FY 2000-2013 time frame. Companies were asked to divulge the total sales of new products and services and other economic results directly related to these SBIR/STTR contracts. This phase lasted for ten months and ran from October 2015 through the end of July 2016. Second, during the *Data Analysis* phase, the research team analyzed the information gathered and used IMPLAN economic-impact assessment software to estimate the total economic impacts resulting from (1) the initial Phase II funding for R&D, and (2) subsequent sales of new products and services derived from the innovations generated by the R&D. This second phase took three months and extended from June 2016 through August 2016. The *Final Report Generation* phase occupied most of the August-September 2016 period. A timeline of the study is depicted below in Table 1. Specific activities undertaken during the first two phases are subsequently described.

Table 1. Timeline of the Navy SBIR/STTR Program Economic-Impact Study

Phases	Oct '15	Nov '15	Dec '15	Jan '16	Feb '16	Mar '16	Apr '16	May '16	Jun '16	Jul '16	Aug '16	Sep '16
Data Gathering												
Data Analysis												
Final Report												

Data Gathering

To enable TechLink to undertake this study, the Navy SBIR/STTR Program provided essential information on all Navy SBIR/STTR Phase II contracts that were

completed (per established Navy criteria) during the FY 2000-2013 period.[8] The study focused exclusively on Phase II contracts because Phase I contracts are strictly intended to investigate the feasibility of new technology concepts. Unless followed by subsequent Phase II funding, Phase I contracts rarely lead to new commercial products and services. The study included a total of 2,734 completed Phase II contracts awarded to 1,199 different companies.

Information provided for each completed Phase II contract was entered into a custom database developed for this study, to facilitate data gathering and analysis. Essential Phase II contract information included the company name and location; the contract number and award amount; the start and completion dates of the award, including any contract extensions; and the names and contact information for the principal investigator and company executive at the time of the award. Award titles and abstracts, which provide background information on the technology being developed, helped establish connections to any resulting commercial technologies and were especially useful when analyzing companies with multiple SBIR/STTR awards.

A team of five TechLink economic research specialists used the Phase II information and databases to survey the companies involved. They attempted to contact, by email and telephone, all 1,199 Phase II recipients about the outcomes of their 2,734 Navy Phase II contracts. The number of contracts exceeds the number of companies because a sizeable subset of companies included in the study (480, or 40 percent) had two or more Navy SBIR/STTR Phase II contracts. Of this group, 243 companies (20 percent) had three or more Navy Phase II contracts, and 161 (13 percent) had four or more contracts. Among the most frequent participants in the Navy program, 31 companies had ten or more completed Phase II contracts, nine had 20 or more, and one company had 40 contracts. This data-gathering phase lasted from October 2015 through July 2016.

Survey Questions. Companies were asked a series of questions that focused on the economic outcomes and impacts related to their Navy SBIR/STTR Phase II contracts. They were assured that their responses would be treated as confidential information and that, in order to conceal their identity, their responses would be aggregated with the responses of other companies and submitted to the Navy without any company names. Basic questions included the following:

[8] Navy Phase II SBIR/STTR award structures vary considerably by Navy Systems Command. Navy Phase II awardees must generally meet specific performance criteria during their initial Phase II performance period in order to receive full funding to complete their Phase II projects. Navy SBIR/STTR award information is available online at *https://www.navysbirprogram.com/navysearch/search/search.aspx* or *https://www.navysbirsearch.com/*

1) Did your company develop any new products or services based on your Navy SBIR/STTR Phase II contract(s)? If so, what were the total cumulative sales of these new products or services for each contract?[9]

2) Of the total sales for each Navy Phase II contract, what was the dollar value of sales to the U.S. military, either directly or through a prime contractor?

3) Did the Phase II contract(s) lead to any follow-on (non-SBIR Phase I or II) R&D contracts for further development of the technology or technologies resulting from Phase II? If so, what was the total dollar value of these contracts?

4) Did you license any of the technologies developed with Navy Phase II funding to another company? If so, what were the total royalties received from each licensee? (Please provide the name[s] of the licensee[s] so we can follow up to ask about sales.)

5) Did you create a spin-out company to commercialize any of the technologies developed with Navy SBIR/STTR Phase II funding? (Please provide the name of the company, so we can ask it about its sales.)

6) Did you receive any significant subsequent investment funding, such as venture capital or angel funding, directly related to the technology developed or commercialized? If so, what was the total amount of these investments?

7) Was your company acquired as a direct result of the technology or technologies developed with Navy SBIR/STTR Phase II funding? If so, what was the acquisition amount?

Response Rate. Companies surveyed provided definitive information on the outcomes of 2,379 contracts out of the 2,734 total—a response rate of 87 percent. However, TechLink researchers were able to obtain authoritative secondary information on the outcomes of 219 additional contracts from other official sources.[10] Including information from these additional awards, this study achieved an *effective response rate* of 95 percent.

[9] Companies were not asked to report their sales *by year* because this would have greatly increased the burden of responding to the survey and, consequently, lowered the response rate.

[10] These other official sources included Company Commercialization Reports (CCRs) and the Federal Procurement Data System (*www.fpds.gov*). Companies are required to submit a CCR with every SBIR or STTR proposal submitted to the DoD. CCRs are intended to provide a record of prior Phase II projects and the sales and investment resulting from innovations developed under these projects. The Federal Procurement Data System (FPDS) is a database of government contracts. It is managed by the Federal Procurement Data Center, part of the U.S. General Services Administration, and contains detailed information on all government contracts exceeding $3,000.

Only 100 out of the 1,199 Navy Phase II recipient companies either openly refused to participate in the study or were non-responsive, despite multiple efforts to secure the necessary information. An additional 68 companies could not be surveyed because they had ceased to operate as corporate entities. These companies had gone out of business, changed their names, or been acquired by other companies and had left no trails that could be followed.

The primary reasons for the study's high response rate are believed to be the following:

- *Clear communication about the purpose and legitimacy of the study*. Companies were informed that the study's purpose was to quantify the extent to which the Navy SBIR/STTR Program was having a positive impact on the national economy and U.S. defense mission, and that the results would be communicated to Navy policymakers, other government agencies, Congress, and the U.S. public. Companies that questioned the legitimacy of the study were sent a letter from the Navy SBIR/STTR program manager that explained the purpose, confidential nature, and importance of the study as well as TechLink's role in undertaking it.

- *Strong assurance that company-specific information would be kept confidential*. Companies were assured that the Navy was only interested in the overall economic impacts from its SBIR/STTR Program—not in company-specific results. Most companies consider their sales figures to be confidential, proprietary, or business-sensitive. Without the assurance that all responses would be treated as confidential information, few companies would have been willing to divulge their sales information.

- *Extensive research to find current contact information.* Because of the long time span covered by the study and the impermanent nature of many small R&D companies, the contact information for principal investigators and company executives in the Navy SBIR/STTR awards database was no longer valid in many cases. Among other things, telephone area codes had changed; companies had gone out of business, relocated, or merged with other firms; and the key people had changed positions, moved to other companies, retired, or even died. The research team expended extensive time and effort to find people knowledgeable about the outcomes of the Navy SBIR/STTR Phase II contracts.

- *Persistence by the TechLink economic research specialists*. Some companies were contacted more than a dozen times by email or telephone in the attempt to get through to the right person and obtain the necessary information. Several different approaches were tried to secure compliance from recalcitrant companies, including having other team members contact the company, approaching different company personnel, and sending a request by registered mail.

- *Conciseness of the survey.* The survey questions were few in number and relatively easy to answer. In some cases, the research team was able to secure the necessary information over the telephone on the first contact. More commonly, extensive follow-up by phone and email was required, often involving several different company personnel. However, the conciseness of the survey encouraged participation.

NAICS Code Assignments. TechLink next assigned all Phase II recipient companies' contracts to the appropriate 6-digit North American Industry Classification System (NAICS) code or codes.[11] This was an essential step for accurate analysis of the overall economic impacts. NAICS codes are one of the most important inputs to the IMPLAN economic-impact model (described below) and were used to accurately determine the economic multipliers specific to the primary business activities associated with the SBIR/STTR Phase II contracts.

NAICS is the U.S. federal government's standard industry classification system. It is a comprehensive production-oriented system that groups companies and divisions of companies into industries based on the business activities in which they are primarily engaged. NAICS recognizes 1,065 different industrial activities and assigns a unique code to each. NAICS codes can be found at the official U.S. government's NAICS code website (*http://www.census.gov/eos/www/naics/*).

Many Navy SBIR/STTR Phase II contracts had more than one NAICS code. All were assigned one of the primary R&D NAICS code for analysis of the economic impacts resulting from the Phase II R&D activity itself. In addition, if the R&D led to commercial sales or other economic outcomes from the resulting innovations, the research team assigned NAICS codes specific to those economic activities.

For accurate analysis of the economic impacts resulting from the Phase II R&D activity, all contracts were assigned one of the following three primary R&D NAICS codes, listed by order of frequency:

- 541712: Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)
- 541720: Research and Development in the Social Sciences and Humanities
- 541711: Research and Development in Biotechnology

Additionally, as just noted, SBIR contracts that led to new sales of products or services were assigned NAICS codes specific to those business activities. Some were assigned two or more commercial sales-related NAICS codes. For example, if a company sold a new, low-cost sensor to measure the acidity or alkalinity (pH) of marine water, based on its Navy SBIR-developed innovation, and also provided ocean pH-monitoring services, it would be assigned two different NAICS codes for these different business activities. Many companies received funding to further

[11] See Appendix 1 for the NAICS codes assigned to contracts in the study.

develop their Navy SBIR/STTR innovations for specialized government or industry applications. In such cases, they were assigned the appropriate NAICS codes for their sales of R&D services.

The research team used Phase II contract information, data provided by companies during the survey, and the NAICS classification system to identify the appropriate NAICS codes for new sales of products or services. To help expedite the assignment of NAICS codes, the research team used an open source software package, R (*https://www.r-project.org/*), which includes both text-mining and machine-learning algorithms, to match keywords from SBIR/STTR contract titles and abstracts to NAICS code descriptions. The resulting classifications were then carefully reviewed to confirm their accuracy. Additional resources consulted included the federal System for Award Management (*www.sam.gov*), Hoover's (*www.hoovers.com*), the LexisNexis Academic web site (*www.lexisnexis.com*), and a commercial NAICS-related website (*www.naics.com*).

Next, the TechLink research team entered company sales and other economic data and NAICS code information into the custom database developed for this study. The database greatly facilitated data entry from the multiple economic research specialists gathering company information. Once the data were aggregated and carefully validated by the team, the database provided mechanisms for quickly querying and analyzing the data as well as generating a final dataset for economic-impact modeling.

TechLink subsequently submitted the final dataset to the BRD at the University of Colorado Boulder. For each Navy SBIR/STTR contract that had achieved sales, the dataset included a code number to identify the agreement and conceal the company's name, the 6-digit NAICS code for the corresponding product or service, and the total sales figures.

The "sales" category included all sales of new products and services directly related to the technologies developed with the Navy SBIR/STTR funding up to the time of the study (2015-2016), including military sales; follow-on R&D contracts to further develop these technologies for specific applications (defined as sales of R&D services); royalties from licensees of the technologies developed with the Navy SBIR/STTR funding; licensee sales of the licensed Navy SBIR/STTR developed technologies, when this information could be obtained; and sales by spin-out companies of the Navy SBIR/STTR-developed technologies, when this information was available.

Data Analysis

The BRD employed a widely used economic-impact analysis software program, IMPLAN, to estimate the economic contribution effects of the total sales resulting from the Navy SBIR/STTR Phase II contracts. More than 1,500 entities in academia, the private sector, and government use IMPLAN to model economic impacts. It is

employed to determine economic impacts on regions ranging in size from zip code area to county, state, and national levels (*www.implan.com*).

IMPLAN draws on a mathematical input-output framework originally developed by Wassily Leontief, the 1973 Nobel laureate in economics, to study the flow of money through a regional economy. IMPLAN assumes fixed relationships between producers and their suppliers, based on demand, and that inter-industry relationships within a given region's economy largely determine how that economy responds to change. Increases in demand for a certain product or service causes a multiplier effect—a cascade of ripples through the economy. This increased demand affects the producer of the product, the producer's employees, the producer's suppliers, the supplier's employees, and others, ultimately generating a total impact on the economy that significantly exceeds the initial change in demand.

For example, Company X uses its Navy SBIR/STTR Phase II funding to develop a miniature video sensor for shipboard use. It then manufactures and sells a product line of miniature video sensors for various government, industrial, and commercial applications. This requires the company to hire factory workers, who spend their payroll checks on groceries and other goods. In addition, Company X has to purchase various electronic components, optical components, computer chips, and packaging materials from other companies, which also employ workers who purchase groceries and other goods, and so on.

In this example, *direct effects* are the sales of the miniature video sensor developed with Navy funding. *Indirect effects* are the inter-industry purchases of components and supplies needed to manufacture this device. *Induced effects* are the household expenditures as workers spend their payroll checks on goods and services across a wide spectrum of the economy. *Economic impacts* are the sum of direct effects, indirect effects, and induced effects.

Multipliers are the ratio of the overall economic impact to the initial change and are typically derived from the following equation: (direct effect + indirect effect + induced effect) / direct effect. Multipliers are very specific to industry sectors and regions. IMPLAN uses NAICS codes to distinguish between 536 industry sectors recognized by the U.S. Department of Commerce. Each sector has a unique output multiplier because it has a different pattern of purchases from firms inside and outside of the regional economy. Each year, IMPLAN is updated using data collected by various federal government agencies.

In this study, BRD converted the NAICS codes provided by TechLink to the 536-sector IMPLAN input-output model, then applied this model to (1) the Navy SBIR/STTR Phase II R&D activity, and (2) the total sales figures up to the time of the study (2015-2016) that were directly attributable to the sales of the innovations resulting from the R&D activity. As previously indicated, these sales figures included all sales of products and services related to the Navy SBIR/STTR Phase II contracts *completed* during the FY 2000-2013 period. Using IMPLAN, BRD was able

to estimate the sum of the direct, indirect, and induced effects of these sales. The overall purpose of this modeling exercise was to estimate the total economic contribution of these sales to the nation's economy, including total economic output, value added, employment, labor income, and tax revenues.

Sales were assumed to be in 2015 dollars for IMPLAN modeling. Company sales occurred up to the time that the study was conducted (fall 2015 to summer 2016). Some sales date back to the early 2000s. However, companies reported their aggregate sales up to the time that sales information was collected. There was a need to select a reference year for IMPLAN modeling. Use of 2015 as the reference year represents a conservative approach because it does not reflect the relatively higher value of the earlier sales figures due to inflation: a dollar in 2015 was worth 27 percent less than a dollar in 2000.[12]

SURVEY RESULTS

Sales from Navy SBIR/STTR Phase II contracts

Well over half of the Navy SBIR/STTR Phase II contracts resulted in commercialization (see Table 2). Of the 2,734 Phase II contracts, 1,753 resulted in sales—64 percent of the total.[13] Of the rest, 845 (31 percent) did not result in sales and 136 (5 percent) consisted of contracts for which no information was available. Ultimately, the commercialization level achieved by these Navy SBIR/STTR Phase II contracts may be significantly higher—it usually takes two to eight years to convert a new technology into a product. Many of the newer contracts have not yet resulted in sales.

Total cumulative sales from the Navy SBIR/STTR Phase II contracts were nearly $14.2 billion ($14,173,677,281). This equates to average sales of approximately $8.1 million for each of the 1,753 contracts that achieved commercialization. This sales figure is nearly ten times the average contract amount of $827,177. The average sales per contract, when considering all of the Navy Phase II awards, including those without commercialization success, was just under $5.5 million. This is nearly seven times the size of the average contract amount, demonstrating that the Navy SBIR/STTR Program achieved substantial commercialization success from its funding of small R&D companies nationwide.

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[12] Per the U.S. Bureau of Labor Statistics, Consumer Price Index (CPI) Inflation Calculator, available online at *http://www.bls.gov/data/inflation_calculator.htm*

[13] This commercialization level is significantly higher than the 48 percent reported for DoD SBIR/STTR Phase II projects as a whole in the NRC study, National Research Council, 2014, *SBIR at the Department of Defense*, Washington, DC: The National Academies Press. It also is higher than the 58 percent commercialization level achieved by Phase II recipients in the Air Force economic-impact study previously discussed, available online at *http://static.techlinkcenter.org/techlinkcenter.org/files/economic-impacts/USAF%20SBIR-STTR%20Economic%20Impact%20Study%20FY2015.pdf*

Table 2. Sales resulting from Navy SBIR/STTR Phase II contracts, 2000-2013

Navy SBIR/STTR Phase II Contracts	Total Number of Contracts	Percent of Total	Total Sales *$ Billions*
Total Contracts	**2,734**	**100**	**$14.174**
Contracts with sales	**1,753**	**64**	**$14.174**
Contracts without sales	**845**	**31**	--
Companies not responding	**136**	**5**	--

As previously noted, the "sales" category included all of the following sources of revenue from commercialization of the technologies developed with Navy SBIR/STTR Phase II funding:

- Sales of new products and services, including both commercial (civilian) sales and sales to the U.S. military
- Follow-on (non-SBIR/STTR) R&D contracts to further develop these Navy SBIR/STTR-developed technologies for specific applications (these were treated as sales of R&D services)
- Royalties accruing to the Navy SBIR/STTR Phase II contract recipients from sales by licensees of the technologies developed with the Navy funding
- Sales by licensees of the Navy SBIR/STTR-developed technologies—when this information could be obtained
- Sales by spin-out companies that were commercializing the Navy SBIR/STTR-developed technologies—when this information was available

Table 3 shows the total sales from the Navy SBIR/STTR Phase II contracts, broken down by sales category. As this table shows, *commercial (civilian) product and service sales* totaled nearly $3 billion and accounted for 21 percent of the total sales. *Military product and service sales* were nearly $7 billion and constituted 49 percent of the total. This high level of sales indicates that the Navy SBIR/STTR Program is achieving its objective of developing new technology to support the U.S. defense mission.

Table 3. Sales from Navy SBIR/STTR Phase II contracts, by sales category

Sales Category	Total Sales *$ Millions*	Percent of Total
Commercial Product/Service Sales	**$2,992**	**21**
Military Product/Service Sales	**$6,960**	**49**
Follow-on R&D Contracts	**$3,489**	**25**
Royalties from Licensees	**$136**	**1**
Sales by Licensees	**$382**	**3**
Sales by Spin-out Companies	**$215**	**2**
Total	**$14,174**	**100**

Note: Totals may not tally due to rounding

Follow-on R&D contracts to further develop the technologies generated with Navy SBIR/STTR funding totaled nearly $3.5 billion and accounted for 25 percent of the total. This R&D funding came from the government and private sectors and included Phase III contracts. However, this category did not include additional SBIR/STTR awards.[14]

Royalties resulting from licensee sales of the technologies developed with Navy Phase II funding were around $136 million. This category is important because a significant number of companies engaged in SBIR/STTR research choose to remain R&D companies and license successfully developed technologies to other companies for subsequent commercialization. *Sales by licensees* were reported to be $382 million. *Sales by spin-out companies*, 49 in number, totaled $215 million. Creating spin-out companies is another major way that companies engaged in SBIR/STTR research choose to commercialize SBIR-developed technology. Together, the last three categories accounted for slightly more than five percent of the total sales.

The most productive SBIR/STTR Phase II contract generated over $1.2 billion in total combined sales. This amount was nearly twice as large as sales from the second most successful Phase II contract, which had approximately $675 million in sales. A total of 23 Phase II contracts had sales exceeding $100 million; 233 had sales exceeding $10 million; 825 had sales of more than $1 million; and 912 had

[14] The Air Force SBIR/STTR economic-impact study did include follow-on SBIR/STTR awards from non-Air Force SBIR/STTR programs.

sales larger than $827,177, which was the average size of the Navy SBIR/STTR Phase II contract.

Figure 1 below presents a graphic summary of the total sales from all Navy SBIR/STTR Phase II contracts that were completed during the FY 2000-2013 period, broken down by sales category.

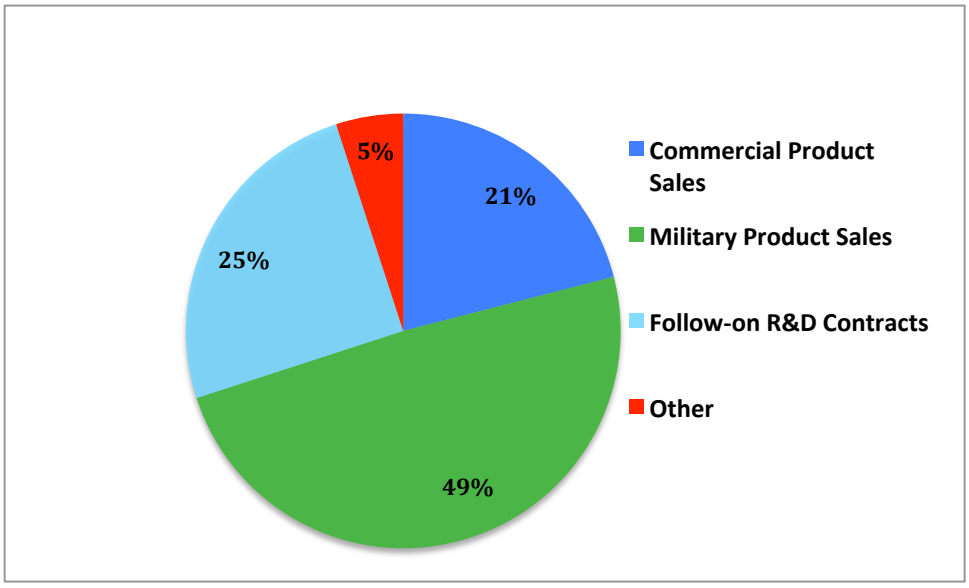

Figure 1. Sales Results by Sales Category

Sales Figures Understate the Reality. For several reasons, total sales figures obtained by this survey are probably significantly smaller than the actual total sales resulting from Navy SBIR/STTR Phase II contracts completed during the FY 2000-2013 period. Reasons include the following:

- *Non-responding companies*. Sales information was not available from a significant number of companies. As previously noted, 168 companies did not participate in the study—100 because they declined to participate and another 68 that could not be contacted because they had ceased to operate as corporate entities. Many of the non-compliant companies are believed to have substantial sales. For example, a sizeable number were large corporations that had acquired Phase II recipient companies because of the commercial strength of the technologies developed with Navy SBIR/STTR funding.
- *Licensee sales information generally unavailable.* The total sales figures also underreport the reality because they do not include most of the licensee sales. Companies reported that they had licensed a total of 130 technologies. However, the TechLink team was able to obtain sales information for only 38 (29 percent) of these licensed technologies. Many companies declined to

identify their licensees or to divulge what they knew of licensee sales. In cases where the licensees were identified and contact information was provided, the licensees proved to be resistant. For the most part, licensees did not feel obligated to participate in this study and were not responsive to requests for information on their sales.

- *Licensee underreporting of sales and underpayment of royalties.* Another reason why the total reported sales, as well as the royalties from such sales, are believed to be substantially larger than this survey discovered is that underreporting is common in the licensing world. Historic royalty audit data from the Invotex Group, a well-established accounting and intellectual property management company, reveals that over 80 percent of licensees underreport and underpay royalties to their licensors.[15] There are various reasons why royalties are underreported. However, the Invotex Group found that at least half of the licenses it audited had underreported sales.
- *Sales information for spin-out companies generally unavailable.* The total sales figures do not include most of the sales by companies spun out of the Phase II recipient companies to commercialize the technologies developed with Navy SBIR/STTR funding. A total of 49 companies reported that they had created spin-out companies. However, the TechLink team was able to obtain sales information for only 16 of these companies (33 percent). As in the case of licensees, most of the spin-out companies did not feel obligated to participate in this study and were not responsive to requests for information on their sales.
- *Inflation.* Finally, inflation contributes to an under-valuation of earlier sales in this study. There were no adjustments for inflation. All sales figures were aggregated and the timing of sales by year is not known. Some sales date back to the early 2000s. Aggregation of company sales values does not preserve the relatively higher value of sales that occurred earlier in the 2000-2013 study period. For example, a dollar in 2015 was worth 27 percent less than a dollar in 2000, and 18 percent less than a dollar in 2005.[16]

For all of the above reasons, the total sales figures reported in this survey are conservative and substantially understate the actual total sales resulting from Navy SBIR/STTR Phase II contracts completed during the FY 2000-2013 period.

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[15] D.R. Stewart and J.A. Byrd, "The Significance of Underreported Royalties-2007 Update: The Magnitude and Meaning of Royalty Misreporting," Invotex Group, Baltimore, MD, February 2007, online at: *www.lawseminars.com/materials/07LICIL/licil%20m%20stewart2.pdf;* D.R. Stewart and J.A. Byrd, "89% of Royalty Revenue is Underreported! Top Five Questions You Should Ask Your Licensee to Avoid Becoming a Statistic," Invotex Group, Baltimore, MD, April 2012, online at: *www.invotex.com/assets/2012_Royalty_Audit_Article.pdf*

[16] U.S. Bureau of Labor Statistics Consumer Price Index (CPI) Inflation Calculator, available online at *http://data.bls.gov/cgi-bin/cpicalc.pl*

Other Economic Outcomes and Impacts

In addition to sales, the companies in the study reported other significant economic outcomes and impacts. The *total outside investment funding* (including venture capital and angel funding) directly related to the innovations developed with Navy SBIR/STTR Phase II contracts was reported to be approximately $646 million. The *number of companies that were acquired* primarily because of the technology developed with Navy SBIR/STTR funding was 91, with a *total acquisition value* reported to be around $1.8 billion. However, this figure grossly understates the actual value. A large majority of acquired companies stated that the terms of acquisition prevented them from disclosing the acquisition amount. Finally, companies in the study reported that they had *licensed 130 technologies* to other companies, and *49 companies reported that they had created a spin-out company* specifically to commercialize technologies developed with Navy SBIR/STTR Phase II funding. These other economic outcomes and impacts are summarized below:

- **Total outside investment funding:** $645,785,104
- **Number of companies that were acquired:** 91
- **Total acquisition value of companies acquired:** $1,795,100,022
- **Number of technologies licensed to other companies:** 130
- **Number of spin-out companies created:** 49

ECONOMIC-IMPACT ANALYSIS

Upon receiving the company sales and 6-digit NAICS code data from TechLink, the Business Research Division (BRD) at the Leeds School of Business, University of Colorado Boulder, used the national IMPLAN input-output model to determine the economic impacts of the Navy SBIR/STTR Phase II contracts completed during the FY 2000-2013 study period. The BRD undertook this task in two stages: (1) IMPLAN analysis of the economic impacts resulting from the nearly $2.3 billion in Phase II R&D activity; and (2) IMPLAN analysis of the sales of the innovations resulting from this R&D. Results below are presented for *output, employment, labor income*, *value added*, and *tax revenues*. As previously noted, all dollar figures are reported in 2015 dollars.

Output

Output is the total value of all goods or services (including intermediate goods and services) produced during a given time period, whether used for further production or consumed. The concept of national output is an integral part of macroeconomics. Output is closely associated with economic-impact analysis and is

one of the values most frequently cited following the completion of economic-impact studies.

Navy SBIR/STTR Phase II R&D Activity. According to the national IMPLAN model, the nearly $2.3 billion ($2,261,502,616) in Navy SBIR/STTR Phase II R&D contracts provided to small businesses throughout the United States generated a total of $6.1 billion in economic output nationwide. Of this amount, around $1.65 billion was generated indirectly as the result of inter-industry purchases (firms purchasing from each other), and $2.19 billion was generated from the induced effect, the result of households spending payroll on goods and services economy-wide (see Table 4).

Dividing the economy-wide output ($6.10 billion) by the direct value of the Navy SBIR/STTR Phase II contracts ($2.26 billion) yields an output multiplier of 2.70. That is, for every dollar in economic activity directly attributable to the Navy SBIR/STTR Phase II R&D, an *additional* $1.70 in economic activity was generated nationwide.

Table 4. Economic Impact of Navy SBIR/STTR Phase II R&D Activity, FY 2000-2013

Impact Type	Employment (Job Years)	Employment (Av. Per Year)	Labor Income (In Billions)	Labor Income Per Job	Value Added (In Billions)	Output (In Billions)
Direct Effect	8,377	598	$0.87	$103,812	$1.16	$2.26
Indirect Effect	10,076	720	$0.63	$62,863	$1.00	$1.65
Induced Effect	13,372	955	$0.68	$50,786	$1.19	$2.19
Total Effect	31,825	2,273	$2.18	$68,567	$3.36	$6.10

Note: Totals may not tally due to rounding

Sales of Navy SBIR/STTR Phase II innovations. In addition to the economic output from Phase II R&D, this study examined the output from the subsequent sales of the innovations resulting from this R&D. According to the national IMPLAN model, the $14.17 billion (2015 $) in direct sales of new products and services reported by companies generated an additional $24 billion in sales economy-wide. Of this amount, $11.77 billion was generated indirectly as the result of inter-industry purchases, and $12.23 billion was generated from households spending payroll on goods and services (the induced effect). The total economy-wide output from sales of the Navy SBIR/STTR Phase II-developed technology was $38.17 billion (see Table 5).

Dividing total economy-wide output ($38.17 billion) by the direct output of companies selling products and services related to their Navy SBIR/STTR Phase II contracts ($14.17 billion) yields an output multiplier of 2.69. For every dollar in sales directly attributable to the Navy SBIR/STTR Phase II contracts, an *additional* $1.69 in sales was generated economy-wide.

Table 5. Economic Impact of Subsequent Company Sales, FY 2000-2013

Impact Type	Employment (Job Years)	Employment (Av. Per Year)	Labor Income (In Billions)	Labor Income Per Job	Value Added (In Billions)	Output (In Billions)
Direct Effect	49,711	3,551	$4.76	$95,665	$6.41	$14.17
Indirect Effect	53,358	3,811	$3.63	$68,097	$5.79	$11.77
Induced Effect	74,734	5,338	$3.80	$50,788	$6.66	$12.23
Total Effect	177,802	12,700	$12.18	$68,530	$18.87	$38.17

Note: Totals may not tally due to rounding

Value Added

Value added is the difference between a company's output and the cost of intermediate inputs. In other words, it is the difference between a product's sale price and its production cost. This measure recognizes that companies buy goods and services from other companies in order to create products of greater value than the sum of the goods and services used to make these products. This increase in value resulting from the production process is the "value added." As estimated by IMPLAN, value added is equal to the total sales (plus or minus inventory adjustments) minus the cost of the goods and services purchased to produce the products sold.

The main difference between output and value added is that output includes the value of intermediate goods and services, while value added does not. Many economists prefer value added as an economic measure because, at the macroeconomic scale, output multiple-counts the value of inputs. For example, in the previously cited case of Company X, which sells a miniature video sensor developed with its Navy SBIR/STTR Phase II contract: Company X purchases electronic and optical components, computer chips, packaging materials, and other supplies to make the sensor device. The value of Company X's sales incorporates the value of these various inputs. Further, each of the companies from which Company X purchases its inputs incorporates the value of their respective inputs from other companies. By combining and aggregating the values of intermediate and final products, output overstates the size of the US economy by a factor of roughly two. For this reason, Gross Domestic Product (GDP), a measure of value added, is used to track the size of the U.S. economy because it is a non-duplicative aggregation of production across all industries in the United States. In the current study, value added measures the real contribution that the Navy SBIR/STTR Phase II contract recipients made to the national economy as a result of receiving that funding.

Navy SBIR/STTR Phase II R&D Activity. According to the national IMPLAN model, the initial nearly $2.3 billion in R&D contracts generated $3.36 billion in value added impact economy-wide. Of this total, $1.16 billion was generated

directly, $1.00 billion was generated indirectly, and $1.19 billion was generated from the induced effect (see Table 4).

Sales of Navy SBIR/STTR Phase II innovations. Subsequent IMPLAN analysis estimated that the $14.17 billion (2015 $) in sales reported by companies generated $18.87 billion in value added impact economy-wide: $6.41 billion generated directly, $5.79 billion indirectly, and $6.66 billion from the induced effect (see Table 5).

Employment

Employment in this analysis refers to the number of jobs created by an economic activity. It is a measure of the number of workers (either full-time or full-time equivalent, if part-time) expressed in "job years" (one full-time position for a year).

Navy SBIR/STTR Phase II R&D Activity. The national IMPLAN model estimated that 8,377 job years were directly created economy-wide by the nearly $2.3 billion in Phase II R&D activity. Indirect effects were responsible for an additional 10,076 job years, and induced effects for 13,372 job years. The IMPLAN model estimates that, altogether, 31,825 job years nationwide resulted from the direct, indirect, and induced effects of the Navy SBIR/STTR Phase II R&D activity (see Table 4).

Sales of Navy SBIR/STTR Phase II innovations. According to the national IMPLAN model, the $14.17 billion in sales directly created an estimated 49,711 job years economy-wide. Indirect effects were responsible for an additional 53,358 job years, and induced effects for 74,734 job years. The IMPLAN model estimates that, altogether, 177,802 job years nationwide resulted from the direct, indirect, and induced effects of the sales of Navy SBIR/STTR Phase II innovations (see Table 5).

Labor Income

Labor income consists of employee compensation (wage and salary payments, including benefits), paid to workers as well as proprietary income (income received by self-employed individuals).

Navy SBIR/STTR Phase II R&D Activity. The national IMPLAN model estimated that labor income directly associated with the nearly $2.3 billion in Phase II R&D activity was $0.87 billion in 2015, or approximately $103,812 per job (see Table 4). This was 115 percent higher than the annualized average wage in the U.S. in 2015 of $48,320.[17] The indirect labor income was estimated at $0.63 billion, or approximately $62,863 per job. The induced labor income was estimated to be $0.68 billion, or $50,786 per job. Average wages for the indirect and induced jobs were substantially lower than the average wage for the jobs directly created

[17] *http://www.bls.gov*

because many of these jobs were in lower-paid manufacturing and service sectors. The total economy-wide labor income resulting from the Navy SBIR/STTR Phase II R&D activity was $2.18 billion. The average wage of the approximately 31,825 jobs created as a result of the Navy SBIR/STTR Phase II activity was $68,567, approximately 42 percent higher than the average U.S. wage of $48,320 in 2015.

Sales of Navy SBIR/STTR Phase II innovations. According to the national IMPLAN model, the labor income directly associated with the $14.17 billion in sales reported by companies was $4.76 billion in 2015, or $95,665 per job (see Table 5). This was *nearly twice* the average U.S. wage in 2015. The indirect labor income was estimated at $3.63 billion, or approximately $68,097 per job. The induced labor income was estimated to be $3.8 billion, or $50,788 per job. The total economy-wide labor income resulting in 2015 from sales of the Navy SBIR/STTR Phase II innovations was $12.18 billion. The average wage of the estimated 177,802 job years created as a result of the Navy SBIR/STTR Phase II contracts was $68,530, which is 42 percent higher than the average U.S. wage in 2015.

Tax Revenues

Tax revenues were estimated for the nearly $2.3 billion in Navy Phase II R&D activity and $14.17 billion in subsequent sales, including their associated economy-wide indirect and induced effects. These tax revenues included social insurance taxes such as Social Security and Medicare (paid by employers, employees, and the self-employed), personal income taxes, motor vehicle licenses, property taxes, corporate profits taxes and dividends, and indirect business taxes (comprised mainly of excise and property taxes, fees, licenses, and sales taxes). Total taxes collected by federal, state, and local government entities were estimated at $4.90 billion. This included $1.57 billion in tax revenues on direct sales, $1.48 billion on indirect sales, and $1.85 billion on induced sales (see Table 6).

SUMMARY

In summary, this study estimated the economic contribution to the U.S. economy of Navy SBIR/STTR Phase II contracts completed during the FY 2000-2013 period. Its purpose was to determine the extent to which these contracts both contributed to new economic activity and job creation in the United States, and resulted in the transition of new technology to U.S. military use.

The research team surveyed 1,199 companies that completed SBIR/STTR Phase II contracts from the Navy during the FY 2000-2013 period. A total of 2,734 Phase II contracts were included in the study because some companies had multiple contracts. Companies were asked to divulge the total sales of new products and services directly related to their Navy SBIR/STTR Phase II contracts. The research team also asked them about their related sales to the U.S. military (either directly or through a defense contractor) as well as follow-on R&D contracts, licensing revenue, and sales by licensees and spin-out companies.

Well over half of the Navy Phase II contracts—64 percent—resulted in sales of new products and services. Companies reported $14.17 billion in total sales and nearly $7 billion in military product sales. Other significant economic outcomes included outside investment funding of nearly $646 million, 91 companies sold to larger corporations with a total acquisition value of at least $1.8 billion (the majority of companies were unable to disclose the acquisition terms), 130 technologies licensed to other companies, and a total of 49 new spin-out companies.

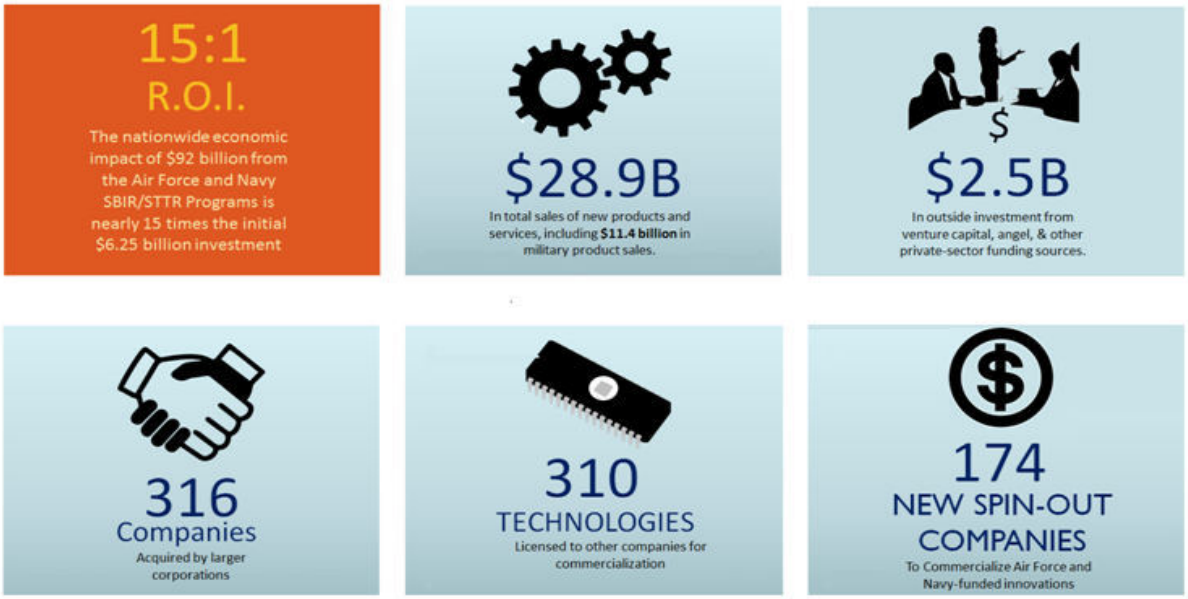
IMPLAN economic-impact assessment software was used to estimate the total economic impacts related to both the Navy SBIR/STTR Phase II R&D activity and subsequent sales of new technologies developed with this R&D. Impacts analyzed included economic output, value added, employment, labor income, and tax revenues. Total economy-wide sales, as measured by output, were estimated at nearly $44.3 billion. Value added was estimated at $22.2 billion, representing new wealth creation in the economy. Labor income in 2015 was estimated at $14.4 billion. Employment impacts included 209,627 total job years, or an average of 14,973 jobs per year, with an average wage of $68,535. Total tax revenues (federal, state, and local) were estimated at $4.9 billion. Table 6 summarizes the total economic contribution of the Navy SBIR/STTR Program.

1156 15th St NW
Suite 502
Washington, DC 20005
www.sbtc.org

SBTC
Small Business Technology Council

SBIR/STTR: The Best Return for the Taxpayer Dollar

Recent Air Force & Navy SBIR/STTR Economic Impact Studies have shown remarkable impact on the American economy. These include economic returns in excess of $15 for every dollar spent,[1] plus improved military strength and capability, significant DoD cost-savings, further economic impacts from new industries with new products and services, new life saving medical techniques and products, and added sales and profits (not counted in the studies) at other companies from acquisitions of the new technology businesses and licensing of their new technologies. The small percentage of DoD R&D invested in the SBIR program is producing outsized returns.



The research teams used IMPLAN economic-impact assessment software to estimate the total economic impacts related to both the $6.25 billion in Air Force and Navy Phase II contracts and the subsequent $28.9 billion in sales of new technologies. Results included:

$92.1B Total economic output nationwide

$46.9B In value added, nearly **8X** the SBIR/STTR Investment

$29.8B In labor income

31,724 Average new full-time jobs per year

Furthermore, the US Navy's study into the economic impacts of the SBIR/STTR program showed that there is a $2.13 return in tax receipts for every $1 dollar invested into the SBIR/STTR program. Thus, SBIR not only creates good paying American jobs and keeps the US ahead of China, Europe, and the rest of the world technologically; it acts like a printing press to create new money, **more than two tax dollars returned for every dollar invested**.[2]

1 Techlink. , 2018: "National Economic Impacts from the Air Force and Navy SBIR/STTR Programs, 2000-2013"
[2] US Department of the Navy: "SBIR/STTR By the Numbers", 2018

June 2018

Earlier this year, the Section 809 panel, which was tasked with finding ways to streamline and improve acquisition at the DOD, released a report offering its recommendations. After praising SBIR for generating "positive outcomes for participants and the government" and creating a direct connection between innovative technology companies and the acquisition community. **The 809 Panel recommended more than doubling the SBIR allocation, to 7%, and making it permanent**.[3]

How to Improve SBIR/STTR

1) Reject HR 5515 Sec 858 – SBIR/STTR Budget Justification

   The House FY '19 NDAA included a separate budget justification requirement at the DOD for the SBIR/STTR program. This requirement is unnecessary, burdensome for SBIR/STTR offices to comply with, and could open the door for the DOD to potentially supersede Congress's authority to set funding for these programs. Congress should make sure this requirement is not included in the final version of the NDAA

2) SBIR/STTR Allocation increase to 7% at DOD

   Follow the Section 809 Panel's recommendation to double the SBIR allocation to further unleash high-tech small business' innovative and economic potential. We should feed success; successful investments should receive increasing investment.

3) SBIR/STTR Permanency

   The SBIR program has a proven, successful track record for over 35 years, and STTR for over 25 years. The program has demonstrated the innovation and unparalleled productivity of American small business skill, hard work and entrepreneurship. The programs should be made permanent to enable the sustained investment and returns that come from longer term perspectives.

4) Separately fund pilot programs without reducing SBIR/STTR funding.

   First authorized during the 2011 Reauthorization, these draw funding from the STTR program and reduce awards to small innovative firms and their university partners. The pilots should be formally evaluated and, if justified, provided separate funding.

5) Require DFAR and FAR regulations updates within one year for SBIR/STTR statutory changes.

   The FAR and DFARS regulations have not been updated to reflect new laws in this area, resisting Congressional actions and the impact of improvements over time. Congress should include a provision requiring the DFAR and FAR regulations be updated and compliant with the law in a timely manner.

3 DOD Section 809 Panel, Jan. 2018: "Report of the Advisory Panel on Streamlining and Codifying Acquisition Regulations", Subrecommendation 21b.

1156 15th St NW
Suite 502
Washington, DC
20005
www.sbtc.org

July 9, 2018

Mail Stop: Patent Board
Director of the United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
Attn: Vice Chief Administrative Patent Judge Michael Tierney
PTABNPR2018@uspto.gov

Subject: PTAB Notice of Proposed Rulemaking 2018 **(Docket number: PTO-P-2018-0036)**

Reference: https://www.federalregister.gov/documents/2018/05/09/2018-09821/changes-to-the-claim-construction-standard-for-interpreting-claims-in-trial-proceedings-before-the

Dear Director Iancu:

The Small Business Technology Council (SBTC) is the nation's largest association of small, technology-based companies in diverse fields. We are a council of the National Small Business Association (www.NSBA.biz) which is the nation's first small-business advocacy organization. NSBA is a staunchly nonpartisan organization with 65,000 members in every state and every industry in the U.S. SBTC advocates on behalf of the 6000 firms who participate in the Small Business Innovation Research (SBIR) program. With less than 1.7% percent of Federal R&D, SBIR/STTR firms have created over 20 percent of America's major innovations, and as many patents as all universities combined; plus we are creating sustainable manufacturing and service jobs in the U.S. Small businesses produce 16 times more patents per employee than large patenting firms, which has a direct correlation with job growth.

The subject proposed rule change is an important start to reversing the devastating effects that the America Invents Act (AIA) has had on American innovation. Since the implementation of the AIA after its passage in December 2011, the United States has fallen from its long-standing position as number one to number 11 in Innovation and number 12 in Patent Strength, behind countries such as France, Sweden, Japan, Great Britain, and Singapore.

The AIA created the Patent Trial and Appeals Board (PTAB), which former Federal Circuit Chief Judge Randall Rader called "death squads killing property rights." The PTAB allows repeated challenges of already approved patents, interfering with the companies right to utilize their patent. Most patents that had already been granted, but later went through the PTAB trial process have had claims invalidated, but that is not the worst of it. The PTAB delays inventors from obtaining clear title to their inventions. The PTAB can hold up the enforceability of patents by months or years, and has even overturned district court decisions. The life of a patent is limited already, and the PTAB

prevents the immediate commercialization of new innovations. This has negatively affected America's funding of new businesses. In 2006, 81% of the global venture capital came to the US, but since the AIA went into effect, the US's share of global venture capital dropped to 54%. Even worse, early-stage VC funding is imploding, dropping by about half since the AIA took effect. And China is now filing significantly more patent applications than the US.

What this has meant for the American economy is that new inventing companies are not being created nor growing. In fact, in two-thirds of America's metro areas, companies are dying faster than being birthed. This is having a distressing effect on job growth from small companies. Holding a patent increases startup employment by 36%, sales growth by 51%, and probability of securing venture capital funding by 53%. Thus, encouraging strong patents leads to more good paying new jobs.

Revising the rules for claim construction, making them consistent with the Article III Federal Courts following *Phillips* v. *AWH Corp.,* 415 F.3d 1303 (Fed. Cir. 2005) (en banc).is a very good first step to making the Patent System Great Again. We strongly support and applaud your efforts in this proposed rule change.

The SBTC is happy to continue our support of the Patent Office and the strengthening of patent rights, particularly for small firms and individual inventors.

Sincerely,
Small Business Technology Council

Robert N. Schmidt
Co-Chair

1156 15th St NW
Suite 502
Washington, DC 20005
www.sbtc.org

SBTC
Small Business Technology Council

June 7, 2018

The Honorable Thomas Massie
2453 Rayburn House Office Building
United States Congress
Washington, DC 20515

The Honorable Marcy Kaptur
186 Rayburn House Office Building
United States Congress
Washington, DC 20515

Subject: Support for "Restoring America's Leadership in Innovation Act of 2018"

Dear Congressman Massie and Congresswoman Kaptur:

The Small Business Technology Council (www.SBTC.org) is writing to express our support for your bill Restoring America's Leadership in Innovation Act of 2018 (RALIA), We believe this bill is extremely important in starting to restore the significant decline in American innovation since the passage of the very damaging America Invents Act (AIA).

SBTC is the nation's largest association of small, technology-based companies in diverse fields. SBTC is a council of the National Small Business Association (www.NSBA.biz) which is the nation's first small-business advocacy organization. NSBA is a staunchly nonpartisan organization with 65,000 members in every state and every industry in the U.S. SBTC advocates on behalf of the 6000 firms who participate in the Small Business Innovation Research (SBIR) program. With less than 1.7% percent of Federal R&D, SBIR/STTR firms have created over 20 percent of America's major innovations, and as many patents as all universities combined (**Figure 1**); plus we are creating sustainable manufacturing and service jobs in the U.S. As patents are critical to the success of small businesses, SBTC has been fighting for years for stronger,[1] not weaker, patents.

Although it was obvious to SBTC's members that the America Invents Act would be extremely harmful to small business and independent inventors, the full effect of its devastation is now just being felt. The value of patents and patent assets has decreased by over 60%[2] in the first few years after passage of the AIA (**Figure 2**). America has now fallen to being tied with Italy for number 12/13[3] (from first place) in patent rights. America has dropped to number 11 in Bloomberg's Innovation Index (behind France and Israel), and our slide in innovation is expected to continue.[4]

We certainly appreciate your leadership and work in helping to improve America's competitive position in innovation by helping to restore stronger patent rights. We also support the STRONGER Patents Act introduced by Rep. Stivers and would encourage you to vote for it if it is the only bill to reach a vote on the House floor. But we believe that the RALIA bill is better as it will strengthen patents even more than the STRONGER Patents Act. And strong patents will help improve innovation.

Your RALIA bill will help reverse the detrimental effects of the AIA which has caused a shift in economic power to China and elsewhere overseas. China is overtaking America

in patenting.[5] (See **Figures 3, 4, & 5.**) Patents protect new products and services and the equity they require, and are a key driver for America's future economic strength.

Inventors pay tens of thousands of dollars[6] out of pocket to obtain a patent and frequently wait years for it to issue.[7] Inventing is also high risk, only 5% of patents are licensed or commercialized.[8] Despite the odds against inventors, they still work to make their dream come true. If they are successful in getting a valuable patent, then they have to enforce it in today's *"efficient infringement"*[9] environment. The decreased use of injunctions encourages prolonged litigation. Before the AIA became fully effective, litigation cost $3-5 million and took 3-5 years.[10] Now it takes even longer and is more expensive for the patent holder.

The declining power of American patents has also played a part in the declining investment by venture capital (**Figure 6 & 7**) and by angels (**Figure 8**). This has caused a decline in startups, adversely impacting the economy[11] (**Figures 9, 10, & 11**). This has been particularly detrimental to "flyover" states like Ohio and Kentucky (**Figure 12**).

Patents are critical for small business success (**Figure 13**). They are the shield that allows a company's equity shares and capital expenditures to have protection in building the markets for America's innovative new products. America has been dissipating this shield for several years. I want to thank you for starting to rebuild it.

SBTC is also pleased to work with you to attempt to obtain other sponsors for the RALIA. We would be glad to address stronger patent rights and other issues with you in person.

Sincerely,
Small Business Technology Council

Jere W. Glover	Robert N. Schmidt	Kevin Burns
Executive Director	Co-Chairman	Co-Chairman

Figure 1.

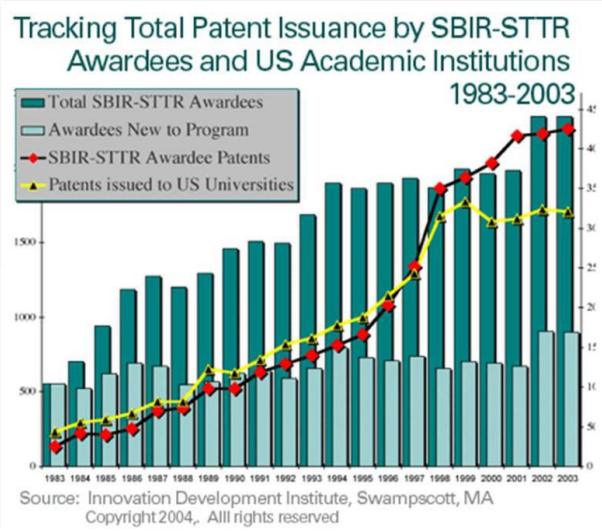


Figure 3

Figure 2

Figure 4

Figure 5

Figure 6

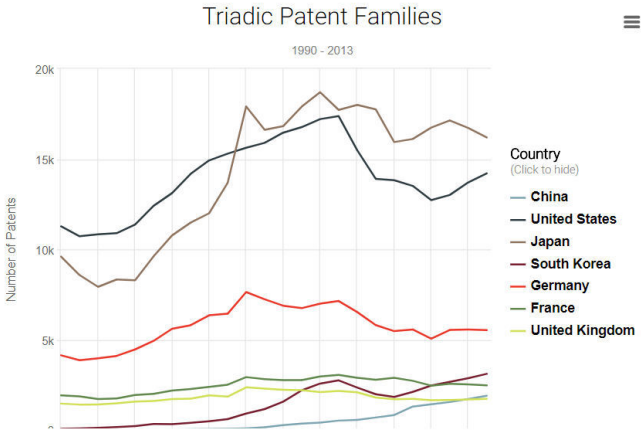
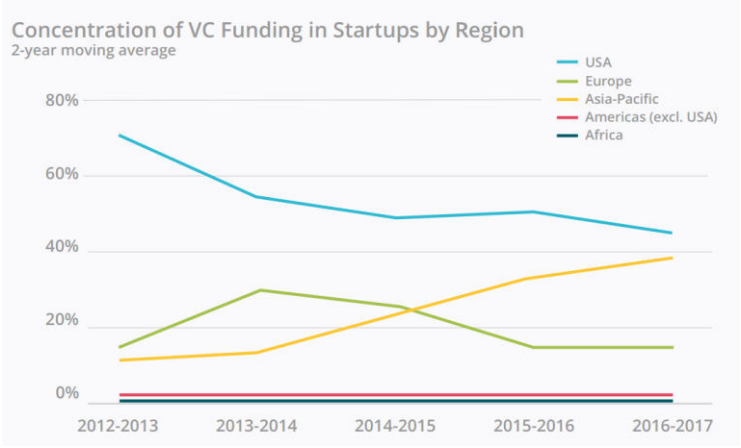
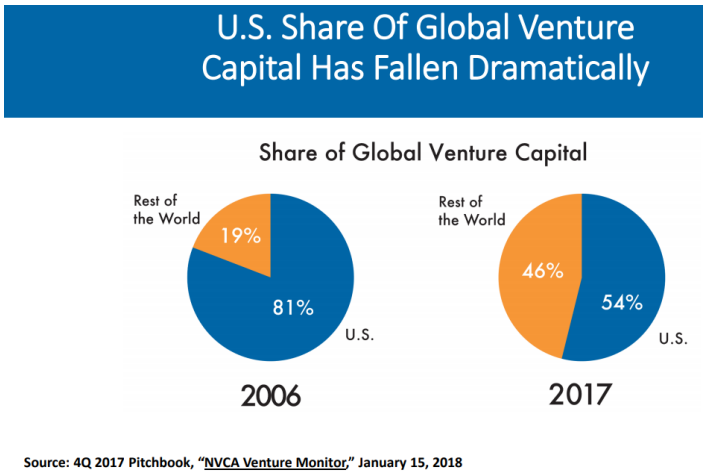


Figure 5 In 2014, China's State Intellectual Property Office (SIPO) processed 34.6 percent of all patent applications in the world. With over 920,000 total applications, China processed 160 percent more application than the United States.



Startup Genome, Global Startup Ecosystem Report, 2018, page 11, https://startupgenome.com/all-report-thank-you/?file=2018

Figure 7



Source: 4Q 2017 Pitchbook, "NVCA Venture Monitor," January 15, 2018

Figure 8

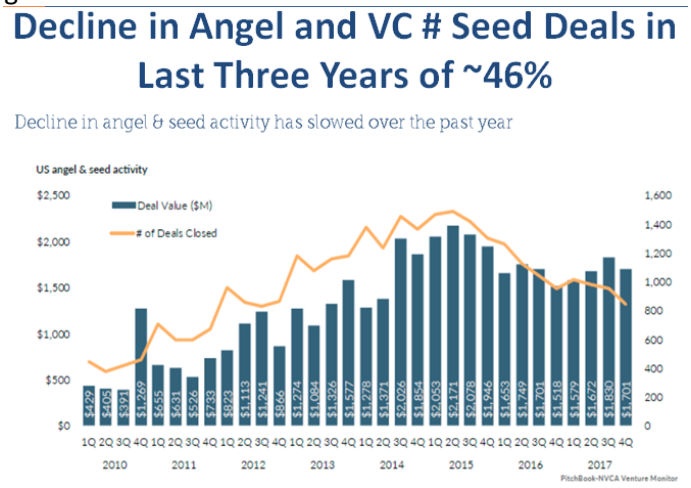


Figure 9

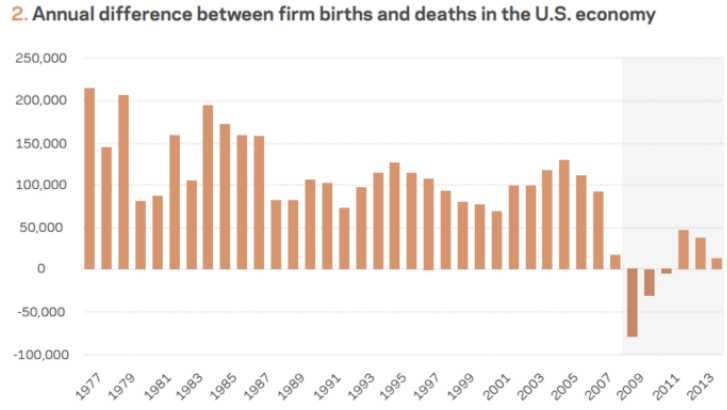


Figure 10

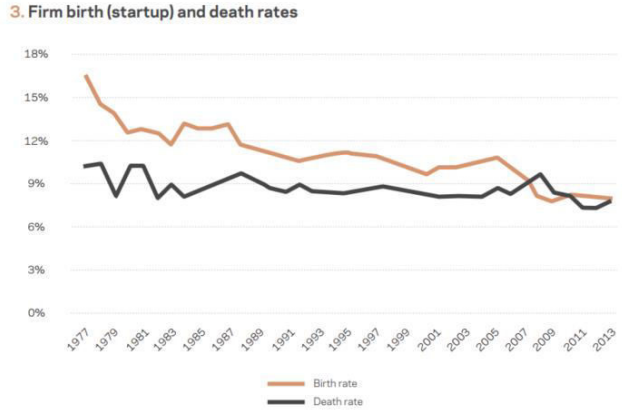


Figure 11

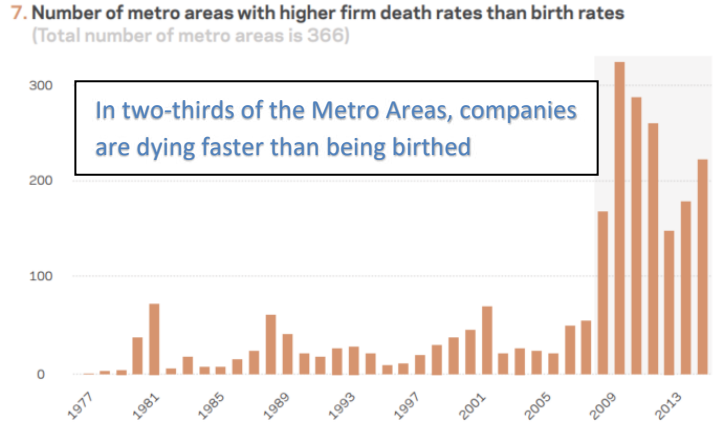
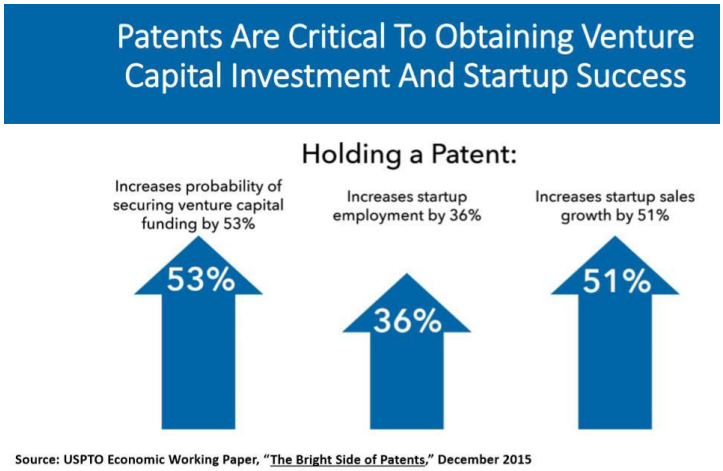


Figure 12

13. The 20 metro areas with the largest declines in firms 2010-2014

Metro Area	Change in firms 2010-2014	Change in employment 2010-2014	Change in employment 2006-2014
Cleveland - Elyria- Mentor, OH	-712	65,600	-28,400
Milwaukee - Waukesha - West Allis, WI	-627	33,000	-16,400
Virginia Beach - Norfolk - Newport News, VA-NC	-455	12,600	-38,300
Youngstown - Warren - Boardman, OH-PA	-420	14,100	-1,200
Hartford - West Hartford - East Hartford, CT	-406	16,300	-12,300
Tucson, AZ	-405	-2,400	-34,300
Providence - New Bedford - Fall River, RI-MA	-383	25,100	-30,000
Cincinnati - Middletown, OH-KY-IN	-371	57,900	2,100
Memphis, TN-MS-AR	-369	16,900	-26,200
Charleston, WV	-369	-1,100	-6,300
Honolulu, HI	-361	25,200	6,300
Toledo, OH	-354	11,700	-22,600
Cape Girardeau - Jackson, MO-IL	-349	-300	-2,100
Knoxville, TN	-333	24,000	5,200
Duluth, MN-WI	-305	2,200	2,700
Mobile, AL	-302	-400	-9,100
Wichita, KS	-276	9,600	4,700
Dayton, OH	-270	13,400	-46,800
Louisville/Jefferson County, KY-IN	-266	45,900	16,800
Topeka, KS	-250	400	-1,500

Figure 13


Patents Are Critical To Obtaining Venture Capital Investment And Startup Success
Holding a Patent:
Increases probability of securing venture capital funding by 53%
Increases startup employment by 36%
Increases startup sales growth by 51%
53%
36%
51%
Source: USPTO Economic Working Paper, "The Bright Side of Patents," December 2015

References:

[1] http://sbtc.org/house-judiciary-marks-up-and-sends-innovation-act-to-house-floor/
[2] An augmented market approach to patent portfolio valuation, Jack Lu, IAM, Sept/OCT 2016, http://www.iam-media.com/Magazine/Issue/79/Features/An-augmented-market-approach-to-patent-portfolio-valuation
[3] *Create*, US Chamber International IP Index, Sixth Edition, February 2018, Figure XI: Scores, Category 1: Patents, Related Rights, and Limitations.
[4] The U.S. Drops Out of the Top 10 in Innovation Ranking, Michelle Jamrisko and Wei Lu January 23, 2018, https://www.bloomberg.com/news/articles/2018-01-22/south-korea-tops-global-innovation-ranking-again-as-u-s-falls.
[5] "And in three of the last four years, at least half of the top ten largest venture investments in the world have occurred outside the U.S." Statement of Scott Kupor Managing Partner, Andreessen Horowitz Chair-elect, National Venture Capital Association before the U.S. Senate Small Business Committee on "Searching for Capital: How Venture Capitalists and Angel Investors Fund Entrepreneurs and Startup Companies" July 14, 2016.
[6] HIGH TECHNOLOGY ENTREPRENEURS AND THE PATENT SYSTEM: RESULTS OF THE 2008 BERKELEY PATENT SURVEY, BERKELEY TECHNOLOGY LAW JOURNAL, Stuart J.H. Graham, Robert P. Merges, Pam Samuelson, & Ted Sichelman, http://ssrn.com/abstract=1429049 The Berkeley study found that the average out-of-pocket cost to obtain a patent was over $38,000 (not including invention costs).
[7] Many of SBTC's members wait 6-8 years (and we have an example of a 12-year wait) for a US patent to be issued in arts such as medical devices or aerospace.
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