

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,

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.

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.

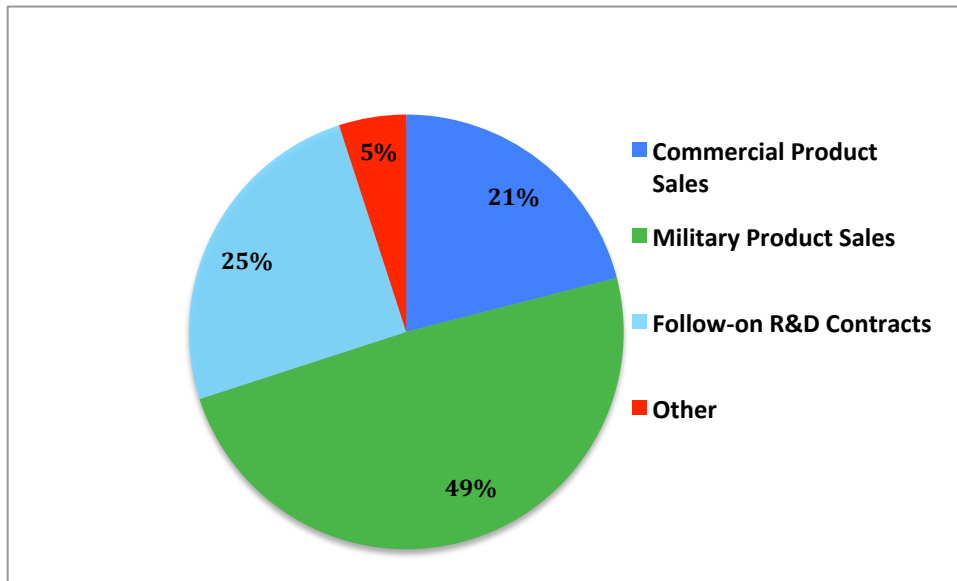


Figure 1. Sales Results by Sales Category

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.

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.