THE ECONOMIC CONTRIBUTION OF THE DEPARTMENT OF THE NAVY TECHNOLOGY TRANSFER PROGRAM

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DEPARTMENT OF THE NAVY
Technology Transfer Program Office

The Economic Contribution of the Department of the Navy Technology Transfer Program

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EXECUTIVE SUMMARY

Technology transfer (T2) agreements can have significant economic benefits in the civilian sector, especially for small, entrepreneurial start-up companies that are the backbone for innovation and economic growth.

The Indiana Business Research Center (IBRC) collected operating and financial data for more than 100 T2 agreements ("deals") with naval laboratories. These T2 deals are directly responsible for 670 jobs. Of the 103 agreement partners—predominantly firms but also including universities and nonprofits—most provided employment data, reporting that these deals created or maintained over 400 jobs (see **Table 1**). The IBRC estimates that T2 agreements directly supported more than 260 additional jobs based on the expanded economic output associated with the agreement partners that did not answer the employment questions.

Two-thirds of the agreement partners that participated in the survey were small, with fewer than 100 employees, as shown in **Table 2**. More than half of the small T2 partners reported that, on average, 12 jobs were created or retained as a result of their T2 agreements, highlighting the noteworthy effect that T2 agreements can have on small, innovative start-up companies.

For every job that T2 agreements directly support, an additional three jobs are created in the civilian economy through economic ripple effects. The T2 deals considered in this study, therefore, are responsible for supporting more than 2,600 civilian jobs.

Table 1: Employment Directly Attributed to T2 Agreements

Agreement Type	New Jobs	Retained Jobs	Total
CRADAs	117	66	183
PLAs	129	94	223
Subtotal as Reported by Survey Respondents	246	160	406
Estimated employment for respondents that did not report employment statistics			264
Total Direct Employment			670

Table 2: T2 Respondents by Company Size

Size of Organization	Respondents %
	N=84
Very Small (1 to 9 employees)	32%
Small (10 to 99 employees)	35%
Medium (100 to 499 employees)	16%
Intermediate (500 to 999 employees)	0%
Large (1,000 to 4,999 employees)	5%
Very Large (5,000+ employees)	13%

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The estimated direct economic output associated with these 103 agreements totaled $200 million. The economic ripple effect of this output generated an estimated $345 million in additional economic activity. Thus, the economic impact of these T2 deals for the civilian economy totaled over a half billion dollars (in 2009 dollars). The federal, state and local taxes generated by this economic activity are estimated to total $60 million, averaging nearly $614,000 per agreement (see **Table 3**).

Of the 103 deals considered in the report, 64 percent were cooperative research and development agreements (CRADAs) and 30 percent were product license agreements (PLAs), with the balance consisting of limited purpose-CRADAs (LP-CRADAs). On average, a CRADA supported over eight jobs while a PLA, on average, supported 10 jobs.

Compared to the U.S. average compensation per worker of $56,100, the direct T2 compensation per full-time job averaged $79,300 per year.

In contrast to a return on investment (the percentage return of a one-time capital expenditure that is generated annually from an investment) or a benefit-cost analysis (the comparison of the total dollar cost of a project or activity with the total dollar benefits), the "economic impact" of a project or a company is a one-year snapshot that measures the dollar and employment magnitude of the economic activity generated by that project or by the presence of that company. The economic impact, or economic footprint, can be compared to the size of an economy (gross domestic product) or the number of people employed in a region, state or country.

The estimated economic impact presented in this report applies only to the agreement partners that participated in the study. The economic footprint of these 100-plus deals cannot be considered averages for all Department of Defense T2 agreements or agreement partners. It would be inappropriate, therefore, to extend the results to the universe of all T2 agreements.

Table 3: Economic Impacts of T2 Agreements

	N=103
Direct Economic Effect	$200 million
Estimated Economic Ripple Effects	$345 million
Total Economic Impact	$545 million
Estimated Taxes Generated from Economic Activity	$60 million
Average Compensation per Full-Time Job	$79,300/year

"Compared to the U.S. average compensation per worker of $56,100, the direct T2 compensation per full-time job averaged $79,300 per year."

Purpose of Study

The Indiana Business Research Center (IBRC) at Indiana University's Kelley School of Business was commissioned to quantify the economic contribution of technology transfer (T2) from Department of the Navy laboratories (DoN labs) to the civilian sector, consisting predominantly of companies and university partners. The T2 agreements (or "deals") assessed in the study included cooperative research and development agreements (CRADAs), patent license agreements (PLAs), and limited purpose-CRADAs (LP-CRADAs) that involve research, technology transfer, technology transition and technology licensing. This report systematically quantifies and summarizes the economic impact of T2 agreements—employment, economic output and productivity—for more than 100 companies and other deal partners.

This report presents the economic impact of these T2 agreements. The economic impact, or economic footprint, refers to the magnitude of the economic activity associated with a business or other economic entity—e.g., a university or DoN lab—that may be compared to gross domestic product for a county, state or country.

This report begins by noting the limitations of the study findings to ensure that the reader interprets the results in their proper context. Second, the methodology is presented. Third, the findings are discussed in terms of company size and agreement type. Fourth, the report presents the estimated economic impact of T2. Finally, there is a discussion about future directions for research on T2.

Limitations

The findings of this study should not be generalized to all T2 agreements or agreement partners. Constraints on data collection and the inability to scientifically select a sample of agreement partners imply that the results do not necessarily apply to all T2 deals. The T2 database provided for this analysis does not include details about partner companies (and universities or other entities) that would allow researchers to make statistical inferences about T2 partner firms that did not participate. The reader should therefore not use the results from participating partners to extrapolate the economic benefits to any other T2 partner or set of partners.

The research team encountered several limitations that affect the study findings. Foremost, in the interest of DoN confidentiality considerations, the database provided by the DoN did not include points of contact for deal partners. In most cases, the IBRC team sent letters encouraging firms to participate in the survey to the president of the company in the hope that the letter would reach the appropriate person. In many if not most cases, the research team garnered the name of the company president from Internet searches or business databases such as Dun and Bradstreet. This strategy worked in general, but there were sometimes considerable delays from the time the letter was sent until the appropriate person received the letter. In one case, a contract manager did not receive the survey invitation until after the survey had closed (about two months after the initial mailing).

The cooperation of the company and the "ORTA" (managers of T2 activity, based in the Office of Research and Technology Applications at each DoN lab) was critical. Many ORTAs helped the IBRC by encouraging their contacts at the various partner companies to complete the survey without disclosing the contacts to the IBRC. Because the ORTAs are considered trustworthy sources and would be able to convince the partner firms that the T2 research and the survey were supported by the DoN, the IBRC asked ORTAs to use their email contacts with their partner companies to promote the survey. Although it was not optimal to be heavily dependent on the ORTAs for distributing the survey information, this allowed the contact information to remain confidential. While confidentiality remained intact, the research team was so constrained by the lack of information about the agreements and partner firms and inability to contact partner firms directly that the ability to complete the study was in jeopardy. Were it not for additional data provided by TechLink (see the methodology section for details), the study would not have been able to hit the 100-deal threshold.

This study does not report a return on investment (ROI)—the percentage return of a one-time capital expenditure that is generated annually from the investment—because capital expenditure data for the DoN labs and agreement partners were not available. Neither does this study present a benefit-cost analysis that compares the total dollar cost of a project with the total dollar benefits over the life of the project. In order to calculate the benefit-cost ratio, one would need detailed expenditure data for DoN compensation, materials and capital, as well as partner compensation, material input, capital expenditures and associated revenues for each T2 agreement.

Methodology

The Department of Navy provided the Indiana Business Research Center data on more than 2,000 CRADAs, PLAs and LP-CRADAs from 1999 to mid-2009. These data included the agreement number (if available), start year of agreement, agreement subject, and the industry partner's name (if available), address, and phone number. Using this information as a foundation, the IBRC researched partner entities via web searches and business information databases such as Dun and Bradstreet to identify potential points of contact, verify the existence of the companies and other company details. About 800 agreements were removed from consideration because partner information was inadequate or non-existent. It is likely that many of those companies removed from consideration had changed names or ownership and were, as a result, not traceable. Given that the goal of the study was to measure the economic benefits of 100 agreements and, the research team reasoned, the longer a start-up company existed the more likely it would be purchased by another firm and thus no longer be traceable, it would be better to survey the partners of the more recent deals. Hence, the research team contacted all T2 partners with a PLA, a CRADA or LP-CRADA in years 2005 to 2009 for a total of 622 T2 partners.

In order to estimate the economic impact of a partner firm's T2 agreement, the research team needed company-level data. As a result, the research team spent several months developing and refining the survey instrument. Early versions of the survey were deployed in two pilot studies in order to determine the best method of obtaining survey results from T2 partners. Based on feedback from the pilot surveys and several conversations with partner firms/individuals about the best way to encourage participation, the team settled on using a web-based survey as the primary means of collecting company information. In addition, the team refined the survey questions and implemented a strategy to encourage participation by encouraging each DoN laboratory's ORTA to advocate on behalf of the research and the survey.

The "deal count" threshold for the study, as specified in the project scope of work, was at least 100 agreements for which to quantify the economic benefits. The final count totaled 103. The majority of data were collected via the survey, with some data gathered from previous research conducted by TechLink.[1] TechLink conducted a study that estimated the economic benefits of the T2 agreements it had facilitated, and the methodology for measuring economic impacts was the same as that used by the IBRC. While the TechLink data collection method was different—they could call their company partners directly while the IBRC had to use a survey—the fact that TechLink used the same method to estimate economic ripple effects allowed for a seamless integration of our results. In order to ensure that the "deal timeframe" was consistent between the survey data and the TechLink data, only 19 of the 70 TechLink study responses were included.

As with the TechLink study findings, the findings from this study cannot be generalized to all T2 agreement partners. Rather, the results provide a snapshot of the economic benefits from the 103 T2 agreements for which the IBRC was able to compile data.

Pursuant to measuring the economic ripple effects of T2, the IBRC research team used the traditional input-output modeling approach to assess the size of the economic linkages and economic impact associated with the T2 agreements. The IMPLAN® modeling system software developed by Minnesota IMPLAN Group, Inc., has been used by more than 1,000 public and private institutions to measure the size of their economic presence in their local or state economies.[2]

A critical data input for IMPLAN analysis is the change in company output due to an "event," in this case the presence of a T2 agreement. The research team relied on the amount of additional annual revenue that survey respondents attributed to their T2 agreements for the change in company output. In some cases, however, survey respondents did not provide responses for their increased revenues. In these instances, the research team used either the change in employment and payroll or the change in the annual dollar value of operating expenses as data inputs for the IMPLAN model.

Three types of effects estimated by the IMPLAN model—direct, indirect and induced effects—are important to understanding the nature of the economic ripple effects generated by the T2 agreements in the United States. Direct effects express the increase in final demand (revenue) or employment that firms experience as a result of their T2 agreements.

Indirect effects measure the change in dollars or employment caused when firms with T2 agreements increase their purchase of goods and services from suppliers and, in turn, those suppliers purchase more inputs and so on throughout the economy. A pharmaceutical manufacturer with a T2 agreement, for instance, will buy test tubes from a supplier. The manufacturer of the test tubes buys electricity to power its plant, buys material inputs for those test tubes and hires people to run the equipment. These transactions constitute the indirect ripple effects associated with the pharmaceutical manufacturer's purchases. The degree to which the money re-circulates in the area's economy—or the magnitude of the multiplier—is determined by whether the manufacturer is located within the geographic unit of analysis. For this study, the entire U.S. was considered the area of interest, so impacts were estimated for the nation as a whole.

Finally, induced effects—whether in dollars or employment—reflect changes in spending that result from the household income of employees that, in turn, change as output changes along the economic supply chain. For example, as a firm's production and sales increases, the output of the supply chain increases correspondingly. Those output changes also result in changes in household income and spending. Induced effects represent the change in overall economic output and employment resulting from those household spending changes.

The total of all economic effects is the size of the economic impact and is the sum of the direct, indirect and induced effects. The IMPLAN model also tracks the tax effects associated with all the transactions and economic activity associated with the direct and ripple effects. For example, household spending at retailers generates state sales tax. In addition, those retailers also pay property taxes to local governments. As a result, this analysis estimated the state and local government tax flows.

The other reported measure is the multiplier. The multiplier is the magnitude of the economic response in a given geographic area associated with a change—either an increase or a decrease—in the direct effects. For example, every dollar of revenue attributed to T2 agreements is estimated to be multiplied by about 2.7 within the United States. Put another way, every dollar of revenue linked directly to a T2 deal generates, on average, an additional $1.70 in economic activity throughout the national economy.

As stated above, the IBRC and TechLink studies used the same method to measure the economic ripple effects but different data collection methods. TechLink provided the IBRC the necessary data inputs for the IMPLAN model, but no other information about the T2 partners other than the agreement number. (The research team used the agreement number to purge those records from its survey sample. Those deal partners did not receive a survey.) As a result, the TechLink data were not as complete as the data collected by the survey. Thus, the descriptive information about the T2 agreement partners, e.g., company size, is limited to the 84 completed IBRC-initiated surveys. See the appendix for a sample of the IBRC survey.

Findings

T2 Company Profiles

The IBRC sent the T2 survey to 622 agreement partners, of which 84 (14 percent) successfully completed the survey. This relatively low participation rate was not unexpected, due to the lack of contact information and the fact that the survey requested primary data on financially sensitive information. The 84 usable survey responses make up the subset of data for the company and agreement type profiles below.

This section first discusses general characteristics of the 84 agreement partners, followed by a breakout of results by company size. Placed in the context of predominantly small company size, the T2 benefits are impressive. The findings are then broken out by type of agreement.

As **Table 4** shows, the majority of the agreements were CRADAs, followed by PLAs and LP-CRADAs. This is consistent with the nearly a 4:1 ratio of CRADAs to PLAs in the T2 deal database.

A large portion of the T2 agreements were with smaller companies—start-ups, spin-offs and other new business ventures by entrepreneurs (see **Table 5** and **Table 6**). Most respondents classified themselves as a small or very small private company. A small percentage of these agreement partners are minority- or woman-owned (14 percent) and four agreement partners reported that they had been DoD laboratory federal employees who spun off businesses.

Most of the agreement partners were in either the manufacturing (42 percent) or the professional, scientific

Table 4: Survey Responses by Agreement Type

Survey Information	Quantity	%
IBRC survey set	622	
Incomplete surveys (useable)	62	10%
Completed surveys	84	14%
CRADAs	61	73%
PLAs	17	20%
LP-CRADAs	6	7%
Usable TechLink agreements	19	
CRADAs	5	26%
PLAs	14	74%

Table 5: Company Size

Size of Organization (Number of Employees)	Survey Set %	Respondents %
	N=622	N=84
Very Small (1 to 9)	11%	32%
Small (10 to 99)	33%	35%
Medium (100 to 499)	14%	16%
Intermediate (500 to 999)	6%	0%
Large (1,000 to 4,999)	7%	5%
Very Large (5,000+)	4%	13%
Unknown	25%	-

Table 6: Organization Type

Organization Type	%
	N=84
Private Company	84%
University or College	2%
Nonprofit (Research)	0%
Nonprofit (Service)	5%
Government	2%
Other	7%

and technical services sector (38.5 percent). Within the manufacturing sector, no one particular industry dominated. However, within the professional, scientific, and technical services sector, nearly two-thirds of the partner firms are in the scientific research and development services industry. The majority of the partner firms in the scientific R&D services industry are located in California or Maryland, with their neighboring states in the West and Mideast also dominating the U.S. R&D landscape.

More than half of the agreement partners had one or more prior experiences with a Department of Defense laboratory in the form of a government contract, Small Business Innovation Research (SBIR) grant, or another CRADA (see **Table 7**). This prior collaboration experience appears to strongly influence the company's desire to pursue additional technology transfer agreements. Fifteen agreement partners reported that their technologies were in perpetual development and it is thus highly likely that their partnerships with DoD laboratories will continue as the technologies continue to evolve. Sixty percent of these continuing agreements were with agreement partners who had CRADAs and the remainder had PLAs.

Profiles by Company Size

In this section, the T2 agreement partners are categorized into three general strata: small (1 to 99 employees), medium (100 to 999 employees) and large (1,000+ employees) organizations.

Medium-sized agreement partners took the shortest amount of time to develop their technology and also experienced the largest increase in the technology readiness levels (TRLs),[5] as shown in **Table 8a** through **8c**. Small and large agreement partners tend to spend more time developing their technology than medium-sized agreement partners and their technology readiness profile appear to be similar, in contrast to medium-sized firms.

When looking at employment results by company size, it becomes apparent that small agreement partners experienced the most growth due to the T2 agreement. About half (51 percent) of the small agreement partners created or retained jobs as a result of the technology, averaging nearly 12 full-time, mostly permanent positions per company at salaries averaging $57,700 (see **Table 9**). Considering their small size, increasing or retaining an average of 12 employees could have a significant impact on the company. Large agreement partners reported an average increase or retention of five permanent, full-time

Table 7: Prior Experience with DoD Laboratory

Prior Experience	%
	N=84
Had Prior Experience?	70%
SBIR[3]	40%
STTR[4]	20%
CRADA	31%
PLA	8%
Government Contract	51%
Other	5%

Table 8a: Technology Development, Small-Sized Partners (1 to 99 Employees)

	Respondent Averages	# of Survey Respondents
		N=56
Time to develop technology (months)	46	42
TRL at beginning	4.0	37
TRL at end	5.7	37
Had prior experience with DoD lab	71%	51

Table 8b: Technology Development, Medium-Sized Partners (100 to 999 Employees)

	Respondent Averages	# of Survey Respondents
		N=13
Time to develop technology (months)	28	6
TRL at beginning	2.6	10
TRL at end	4.9	8
Had prior experience with DoD lab	85%	11

Table 8c: Technology Development, Large-Sized Partners (1,000+ Employees)

	Respondent Averages	# of Survey Respondents
		N=15
Time to develop technology (months)	57	4
TRL at beginning	4.7	13
TRL at end	6.0	12
Had prior experience with DoD lab	80%	10

employees, a modest gain given the initial size of these firms.

Smaller agreement partners also had the most to gain in terms of average annual increases in gross revenue (see **Tables 10a** through **10c**). It is interesting to note that small deal partners have relatively minor increases in expenses associated with the agreements, yet over half (55 percent) either expected or experienced increases in revenue averaging $2.9 million. Conversely, the expense associated with the agreements of large partners averaged $1.1 million, but they expected or experienced relatively modest increases in average annual gross revenue ($502,500). For larger agreement partners, the fact that T2 agreements appear to "lose money" may reflect difficulty in obtaining information across multiple departments (engineering, payroll, finance, etc.).

Profiles by Agreement Type

CRADAs

Sixty-one of the 84 survey respondents had CRADA agreements. From the start of a CRADA to the finish, these

Table 9: Effect of T2 Agreements on Employment by Partner Size

	Small (1 to 99 employees)	Large (1,000+ employees)
Agreement affected full-time employment	51%	20%
Average number of new jobs per company	6.5	3
Average number of retained jobs per company	5.4	2
New or retained jobs that were permanent	96%	100%
Average annual salary of new or retained job	$57,700	$50,000

Notes: Values are calculated based on the number of agreement partners who answered the respective questions. Medium-sized firms reported no effect on full-time employment.

Table 10a: Financial Implications of T2 Agreements for Small-Sized Agreement Partners

	Value or Percentage	# of Survey Respondents
		N=56
Average annual direct expenses associated with agreement	$234,030	36
Experienced cost savings due to agreement	27%	55
Average annual value of cost savings	$57,545	55
Type of cost savings experienced:		
Equipment cost savings	71%	15
Payroll cost savings	21%	15
Research cost savings	50%	15
Material or component input cost savings	36%	15
Other cost savings	14%	15
Expected or experienced increased revenue	55%	56
Average annual increase in gross revenue/company	$2,911,030	32
Increased revenue due to:		
Improved or extended an existing product	34%	32
Increased sales	28%	32
Other	53%	32

Note: The calculation for average annual value of cost savings omits an outlier that originally strongly skewed the results.

Table 10b: Financial Implications of T2 Agreements for Medium-Sized Deal Partners

	Value or Percentage	# of Survey Respondents
		N=13
Average annual direct expenses associated with agreement	$158,945	11
Experienced cost savings due to agreement	39%	13
Average annual value of cost savings	$10,000	13
Type of cost savings experienced:		
Equipment cost savings	40%	5
Payroll cost savings	-	-
Research cost savings	100%	5
Material or component input cost savings	60%	5
Other cost savings	-	-
Expected or experienced increased revenue	15%	13
Average annual increase in gross revenue/company*	-	-
Increased revenue due to:		
Improved or extended an existing product	50%	2
Increased sales	50%	2
Other	50%	2

*Medium-sized companies did not report actual or expected increases in revenue.

Table 10c: Financial Implications of T2 Agreements for Large-Sized Deal Partners

	Value or Percentage	# of Survey Respondents
		N=15
Average annual direct expenses associated with agreement	$1,017,140	12
Experienced cost savings due to agreement	27%	15
Average annual value of cost savings	$673,300	15
Type of cost savings experienced:		
Equipment cost savings	-	-
Payroll cost savings	-	-
Research cost savings	75%	4
Material or component input cost savings	-	-
Other cost savings	50%	4
Expect to or experienced increased revenue	40%	15
Average annual increase in gross revenue/company	$502,500	4
Increased revenue due to:		
Improved or extended an existing product	50%	6
Increased sales	67%	6
Other	17%	6

respondents spent on average nearly 52 months (4.3 years) developing the CRADA's technology, during which time the technology readiness level (TRL) increased almost two levels. The average TRL moved from 3.9 at the beginning to 5.7 the end of the agreement. **Figure 1** presents the TRL profile of the CRADA partners at the beginning and end of their agreements.

Agreement partners entered into CRADAs with several objectives and expected outcomes. As presented in **Table 11**, the top four CRADA objectives are to use the DoN laboratory, further develop the technology, develop a prototype for naval applications, and gain access to material or component input for a product or service. The top four expected outcomes consisted of advancing the research on the technology, developing/improving a technology process, commercializing a product and increasing company profits.

Thirty-six percent of the partners with CRADAs reported that the agreement affected their full-time employment by creating an average of 5.3 new jobs per company. Seventeen of the 22 agreement partners reported that the agreement retained an average of 3.9 jobs. Interestingly, 14 of the 22 agreement partners reported that they created new jobs as well as retained current jobs. The majority (88 percent) of the jobs were permanent. These jobs averaged $67,700 annually and were primarily located mostly in the Far West (33 percent), followed by the Southeast (21 percent) and Mideast (17 percent).[6]

Nearly all of the agreement partners generated CRADA-related expenses (90 percent). Nearly 33 percent reported cost-avoidance or savings due to the T2 partnership. The annual expense associated with the average CRADA in the survey set was around $400,000, with slightly more than half of the expenses devoted to employee compensation (52 percent). The high percentage devoted to employee compensation is due to each company having an average of three employees working on the CRADA's technology.

"Collectively speaking, these 22 agreement partners created or retained a total of 223 jobs, with more than half of these jobs considered permanent."

PLAs

Seventeen of the 84 survey respondents had PLA agreements. The vast majority (82 percent) of them had commercialized their technologies and were at various stages of production at the time of the IBRC survey (see **Table 12**). Compared to CRADAs, PLAs spent less time in technology development (42 months vs. 52 months). The remainder of this section will refer to all PLAs included in the analysis, 17 from the IBRC survey and 14 from TechLink, for a total of 31 PLAs.

Nearly three-fourths (22, or 71 percent) of the agreement partners reported the PLA outcome had affected full-time employment, with several mentioning that their employment numbers were expected to grow in the near future. On average, each partner created nearly six jobs and

Figure 1: CRADAs and Their Technology Readiness Levels

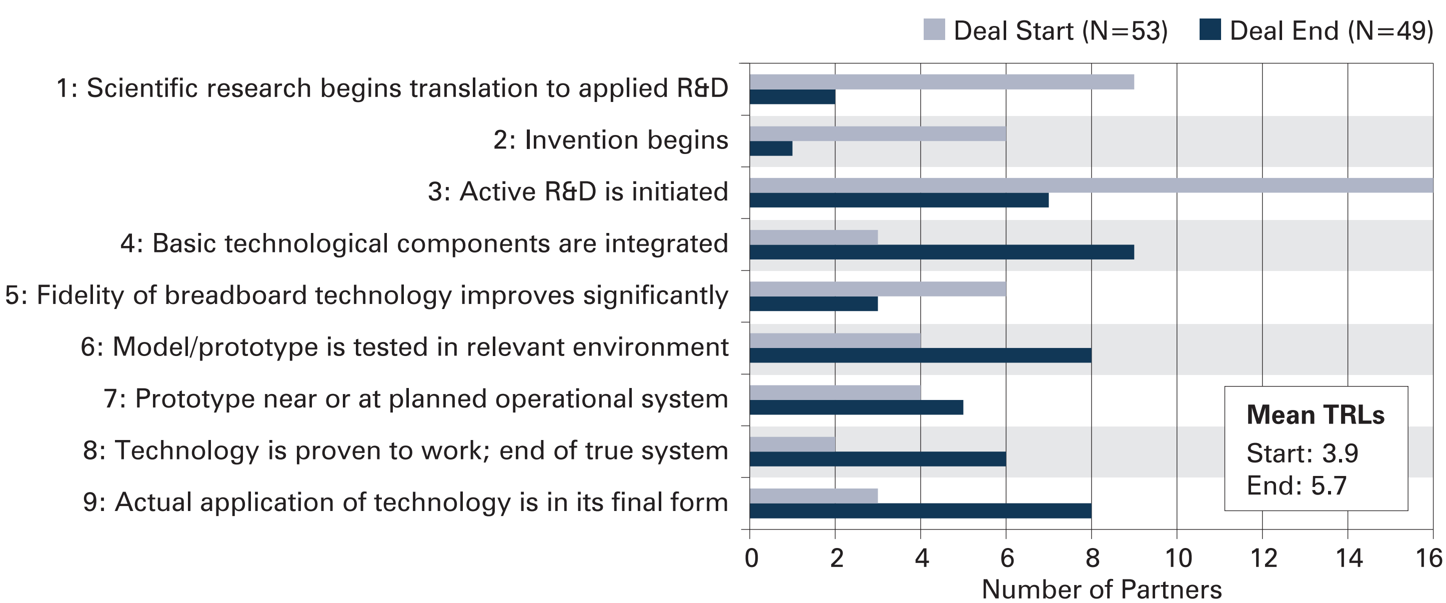

Table 11: CRADA Objectives and Expected Outcomes

Objective	# of Responses	%	Expected Outcome	# of Responses	%
	N=61			N=61	
Use of DoN lab equipment and/ or personnel	24	39%	Advance research on a technology	33	54%
Further develop technology	22	36%	Develop/improve a technology process	32	53%
Develop a prototype for naval applications	16	26%	Commercialize a product	24	39%
Material or component input for a product/service	16	26%	Increase profits for the company	15	25%
Develop a prototype for internal applications	13	21%	Publish a paper on research findings	11	18%
Pure, basic research	11	18%	Enter into a PLA	11	18%
Conduct clinical trials	9	15%	Other	9	15%
Access to software, data, or programming code	8	13%	Develop a commercial off-the-shelf product	6	10%
Other	8	13%	Develop a patentable invention	5	8%
			Submit an invention disclosure	4	7%

Note: Respondents were able to select multiple answers to the question, hence the larger number of responses than the number of CRADA responses

retained about nine jobs. Collectively speaking, these 22 agreement partners created or retained a total of 223 jobs, with more than half of these jobs considered permanent. Similar to the CRADA jobs, they tend to be located in the Far West region (41 percent). Of the 12 agreement partners reporting, average employee compensation was around $53,000.

A PLA technology can have a significant effect on the company's finances. Although only three of the 31 PLA agreement partners reported cost savings, the returns were more evident in the average annual change in profits and gross revenues. Twenty-four of the PLAs (77 percent) reported an average increase of nearly $4.8 million in their gross revenues and 14 agreement partners (45 percent) reported an average profit of $2.3 million. Most (71 percent) of the increased gross revenues were a result of improving or extending an existing product.

Nearly half of the respondents (48 percent) received either new or increased contract work due to the PLA's technology, totaling 138 contracts. These PLA partners received an average of nearly 17 new or additional contracts each at an average value of nearly $11.1 million.

Table 12: PLAs and Degree of Commercialization

PLA Commercialization	%
Commercialized the technology	82%
Current stage of development or commercialization	
Technology/product improvement	0%
Early-stage/start-up production	24%
Initial rollout marketing/sales planning	18%
Full-scale production	18%
Marketing/sales for full-scale production	18%

Eight partners reported that these contracts created or retained 60 full-time jobs within their organization, 75 percent of which are permanent.

Five agreement partners also reported that they had licensed the technology to other entities. The average license duration is nearly 10 years and the average expected annual gross license revenue was reported at slightly more than $4 million.

LP-CRADAs

Only six of the 84 survey respondents had LP-CRADAs, all but one of which was for material transfers. The objectives for those material transfers varied, as **Table 13** shows. Likewise, the ultimate end user of the LP-CRADA varied, but most respondents indicated the end user would be either the U.S. Navy or another DoD agency.

Only one of the six companies intended to commercialize the LP-CRADA technology to civilians. None of the respondents experienced or expected changes in their full-time employment. Some did incur financial expenses averaging $69,000, 73 percent of which were for employee compensation. There were also benefits stemming from the agreement. One company reported $80,000 in cost savings in equipment, research and material or component input expenses. Additionally, one company expected increased revenues due to the technology transfer in the form of payroll savings, but did not provide an estimate of the increased revenues.

IMPLAN Results

The financial impact of the T2 program extends beyond the firms that hold agreements. In order to estimate the economic ripple effects of this program, the research team used the IMPLAN economic modeling software to conduct a standard input-output analysis of the private sector revenues generated by T2 agreements in 2009.

Of the survey respondents, 82 organizations provided the financial information needed to generate economic impact estimates. As mentioned previously, information for an additional 19 companies was provided by TechLink to bring the total number of agreement partners included in the input-output analysis to 101. These T2 agreements generated a total annual economic footprint of $545 million. As **Table 14** shows, $200 million of this total is associated with the direct sales of T2 deal partners. Through those partners' purchases of production inputs and the household spending of employees, this direct output generated another $345 million annually in economic ripple effects throughout the nation. A useful indicator for understanding the economic impact is the multiplier. The ratio of total effects to direct effects yields a multiplier of 2.7. This means that each dollar of output generated directly by these T2 agreements supported an additional $1.70 in economic activity in the broader economy ($1.00 + $1.70 = $2.70).

The level of direct output creates an estimated 670 jobs for these 101 companies with T2 agreements. The ripple effects caused by purchases and household spending support another 1,960 jobs. The resulting employment multiplier of 3.9 indicates that 2.9 additional jobs are created for each new job generated by a T2 agreement. Employment multipliers tend to be higher than output multipliers since household spending (i.e., induced effects) supports many part-time and low-wage jobs in industries such as entertainment, food service and retail.

Another way to consider the impact of T2 agreements is to look at the effects on a per-agreement basis. Given that these estimates are based on data gathered from 101 firms, each T2 agreement in this analysis generates an average of $5.4 million in annual economic output and creates 26 jobs.

Many types of firms or institutions hold T2 agreements. Of the 101 survey respondents, 40 were engaged in some form of manufacturing while another 41 were in a professional, scientific or management field (see **Table 15**). Agreements with chemical manufacturers generated the largest total economic output effect at $154 million annually and the largest multiplier at 3.0. The four firms in the information industry had the largest economic effect per agreement with an average total output of $16 million.

Table 13: LP-CRADA Objectives

Objective of LP-CRADA	# of Responses
Test for the benefit of the Navy	3
Test for potential internal applications	2
Pure, basic research	2
Develop a product/service that uses the technology	2
Other	1
Material or component input for a product/service	1
Further develop the technology	1

Note: Respondents were able to select multiple answers to the question, hence the larger number of responses than the number of LP-CRADA responses

Table 14: Nationwide Economic and Employment Footprint of Selected T2 Agreements, 2009

	Direct Effects	Indirect Effects	Induced Effects	Total	Multiplier
Economic Output ($ Millions)	$200	$190	$155	$545	2.7
Employment	670	910	1,050	2,630	3.9

The numerous agreements in the professional, scientific and management fields had the second highest total economic effect, but averaged $3.2 million in total output per agreement—the lowest mark among these industries.

As shown in **Table 16**, the 41 agreements in the professional, scientific and management industry have the largest total employment effect but the lowest employment multiplier. This is because this industry does not have a large supply-chain footprint. In contrast, manufacturing sectors, with the exception of fabricated metals, have larger employment multipliers due to the relatively large share of their top-line revenue that is consumed by purchasing production inputs—a large supply-chain footprint—which supports employment in other sectors.

The T2 agreement partners tended to be in industries that offer high compensation per job (see **Table 17**). The estimated average annual compensation per job (including wages, benefits and payroll taxes) for each position created by a T2 agreement was $79,300. In contrast, the U.S. Bureau of Economic Analysis reports that average annual compensation for all U.S. jobs in 2008 (the most recent year available) was $56,116.

The increase in revenues and employment attributed to T2 agreements also generate a range of tax revenues paid to federal, state and local governments. The IMPLAN economic modeling software calculates tax revenue estimates from corporate profit taxes, indirect business taxes (e.g., sales, property and excise taxes), personal taxes (e.g., income and property taxes) and employer and employee contributions to social insurance. **Table 18** shows that the 101 agreements considered in this analysis spurred an estimated $62 million in annual tax revenues. That

Table 15: Economic Footprint of Select T2 Agreements by Industry, 2009

	# of Agreements	Direct Output ($ Millions)	Total Output ($ Millions)	Multiplier
Professional & scientific, management and administration	41	$47	$130	2.8
Miscellaneous industries	16	$25	$49	2.0
Chemicals, including pharmaceutical and plastics mfg.	14	$51	$154	3.0
Industrial machinery and miscellaneous equipment mfg.	11	$35	$93	2.7
Computer and electronic equipment mfg.	11	$13	$38	2.9
Information processing and communications	4	$23	$64	2.8
Fabricated metals mfg.	4	$7	$17	2.4
Total	101	$200	$ 545	2.7

Table 16: Employment Footprint of Select T2 Agreements by Industry, 2009

	# of Agreements	Direct Employment	Total Employment	Multiplier
Professional & scientific, management and administration	41	300	860	2.9
Miscellaneous industries	16	60	200	3.3
Chemicals, including pharmaceutical and plastics mfg.	14	80	550	6.9
Industrial machinery and miscellaneous equipment mfg.	11	70	420	6.0
Computer and electronic equipment mfg.	11	20	130	6.5
Information processing and communications	4	110	370	3.4
Fabricated metals mfg.	4	30	90	3.0
Total	101	670	2,620	3.9

Table 17: Estimates of Compensation per Job for Companies with T2 Agreements by Industry, 2009

	Average Compensation per Job
Chemicals, including pharmaceutical and plastics mfg.	$83,400
Computer and electronic equipment mfg.	$90,200
Fabricated metals mfg.	$67,400
Industrial machinery and miscellaneous equipment mfg.	$99,000
Information processing and communications	$70,400
Professional & scientific, management and administration	$75,600
Miscellaneous	$87,600
Total	$79,300

Table 18: Tax Revenues Generated by Select T2 Agreements, 2009

	Federal	State and Local	Total
Tax Revenue ($ Millions)	$39	$23	$62

comes to roughly $613,900 in annual taxes collected per T2 agreement in the survey set.

Future Directions

The goal of this study was to quantify the economic footprint for 100 T2 agreements. The research team also collected rudimentary information on the development of agreement technologies—progress along the technology readiness path—and characteristics of agreement partners. In conducting this research, the team considered how to gain a better understanding of the economic benefits of T2 and how the DoD might maximize the benefits of T2. This experience suggests at least two potential research extensions.

The first extension could investigate the agreements dated between 1999 and 2004. For this report, the research team focused on agreements for naval laboratories between 2005 and 2009 since it becomes increasingly difficult to identify and monitor the agreement entity (and the appropriate point of contact to participate in the survey) over time. However, it may have been more difficult for the respondents to estimate the financial returns and employment benefits for these more recent technology agreements which are often at a lower level of readiness. It has been hypothesized that many types of technology require years of development before their market potential can be fully realized. If so, many of the technologies from pre-2005 agreements may have even greater economic benefits than those chronicled here. It would be desirable, therefore, to survey companies that had T2 agreements before 2005. This would allow a better understanding of the length of time it takes for companies to fully develop a technology after partnering with the DoN laboratory.

This survey would require vigorous ORTA support and assistance. Otherwise, the results of the research would be less robust than this study and yield only tentative conclusions.

The second proposed research extension is to expand the methodology and scope of the survey to attempt to track how a technology from the 1999 through 2004 timeframe developed and evolved. If it indeed takes several years for an agreement to bear significant commercial fruit, the path for high-value technologies could be charted.

There would be challenges, however. Nearly half of the 622 partners in the survey sample were small, i.e., they employed fewer than 100 people, and over 60 percent of the survey respondents were small. Small start-up firms can be the most dynamic and entrepreneurial members of the economy. They can also be the most transient. Many start-ups are acquired by larger firms that, in turn, may be purchased by even larger companies. Tracking the start-ups and their agreement technologies will require even more vigorous ORTA support, assistance, time and resources.

A more comprehensive study would not necessarily need to engage all ORTAs. It may be preferable to select a dozen ORTAs to help facilitate direct contact with a couple dozen partners to flesh out how technologies evolve and move from the lab to the market. The research would be more akin to a collection of case studies in technology development, but would also include an economic impact analysis. The case study findings could be used as a foundation for the DoD to track and monitor technology transfer and transition in the future.

The case studies could also serve as a foundation for perfecting the method to collect data for measuring the economic benefits of T2, as well as improving the management of the technology transfer and transition agreements. While the method to estimate economic effects is well-established (using IMPLAN and other modeling software), producing unassailable estimates of an economic footprint, or, for that matter, the benefit-to-cost ratio and other measures of economic performance, is predicated upon good hard data. An online survey is not the best method to collect these data. A far superior method would entail a detailed data collection and reporting procedure for both the laboratory as well as the agreement partner. It would take time to design, implement and evaluate such a procedure. Once the procedure was perfected, data for all DoD agencies involved with T2 could be collected. This would, in turn, enhance the measurement of the economic benefits of T2 for all of the DoD. Without being able to measure the economic performance of T2, it is difficult if not impossible to manage it.

Conclusion

Technology transfer not only benefits the warfighter; it can also have significant economic benefits for the civilian sector. An examination of 103 T2 agreements with naval laboratories shows that these deals contribute 670 jobs directly. Those jobs help to support an additional 1,960 jobs throughout the economy.

The estimated direct economic output associated with these 103 agreements totaled $200 million, which in turn generated an estimated $345 million in additional economic activity. The economic impact of these T2 deals thus totaled over half a billion dollars in the civilian economy.

The economic impact of T2 is especially important for small, entrepreneurial start-up companies. It is widely accepted that such firms are the most dynamic and innovative in the economy, representing the engine of future economic growth.

This study focused on 103 agreement partners. The constraints placed on the research methodology limits the ability to extend the results to the universe of all T2 agreements. Extensions and improvements to this study—extending the timeframe and broadening the scope—would require robust commitments and assistance from ORTAs and the Department of Defense offices of technology transfer and transition. The research team recommends a series of technology transfer and transition case studies that could be used as a foundation for the DoD to track and monitor technology transfer and transition in the future and more accurately measure the economic benefits of T2 in the civilian sector.

"The estimated direct economic output associated with these 103 agreements totaled $200 million, which in turn generated an estimated $345 million in additional economic activity. The economic impact of these T2 deals thus totaled over half a billion dollars in the civilian economy."

Notes

1. TechLink helps the Department of Defense commercialize leading-edge new technology by partnering DoD labs with private sector companies for technology licensing, transfer, and research and development. Located at Montana State University, TechLink has worked with approximately 75 percent of the 123 Defense labs and centers nationwide, facilitating more than 650 technology transfer partnerships, including over 200 license agreements. See http://www.techlinkcenter.org/ for more information.
2. Please see the appendix for a more detailed description of the IMPLAN software, or explore the IMPLAN website at: http://implan.com.
3. The Small Business Innovation Research (SBIR) program is a set-aside program for domestic small business concerns to engage in research/research and development (R/R&D) that has the potential for commercialization. Federal agencies with extramural research and development budgets over $100 million are required to administer SBIR programs using an annual set-aside of 2.5 percent for small companies.
4. The Small Business Technology Transfer (STTR) program is very similar to the SBIR program and is funded by federal agencies with extramural research and development budgets over $1 billion annually setting aside 0.30 percent for small businesses. One of the differences between the two programs is that STTR recipients must formally collaborate with a research institution in Phase I and II of the grant.
5. Technology readiness levels (TRLs) indicate the level of technology maturity based on its capabilities for an intended purpose. For example, TRL 1 is the stage of basic science research, and the highest, TRL 9, represents technologies that have passed testing under expected operating conditions. See the sample survey in the appendix for more TRL definitions.
6. These regions are defined by the Bureau of Economic Analysis at http://www.bea.gov/regional/docs/regions.cfm.

Appendix

IMPLAN

Minnesota IMPLAN Group, Inc. is the company responsible for the production of IMPLAN data and software. Using classic input-output analysis, IMPLAN can be used to measure the effect on a regional or local economy of a given change or event in the economy's activity. It also allows the user to build economic models estimating the effects of a proposed industry or economic change in a specific economic region.

How Did IMPLAN Come to Be?

In the late 1970s and 1980s, the U.S. Department of Agriculture's Forest Service found itself wrestling to answer questions about the economic impact of its work. Legislation required the forest service to report annually on the impact of its activities. So the forest service had developed a mainframe computing tool called IMPLAN, short for "impact analysis for planning." The Minnesota IMPLAN Group mission has been to provide affordable, user-friendly software and economic data that their clients can use to study regional economies—not just the effects of lost logging business, but what tourism or manufacturing contributes to the economy, what the results of increased or decreased product demand or employment in a particular industry will be, or how effective government spending is in bringing about economic development.

The Economic Theory behind IMPLAN

IMPLAN is built on a mathematical input-output (I-O) model developed by Wassily Leontief, the 1973 Nobel laureate in economics, to express relationships between sectors of the economy in a chosen geographic location. In expressing the flow of dollars through a regional economy, the input-output model assumes fixed relationships between producers and their suppliers based on demand. It also omits any dollars spent outside of the regional economy—say, by producers who import raw goods from another area, or by employees who commute and do their household spending elsewhere.

The idea behind input-output modeling is that it's the inter-industry relationships within a region that largely determine how that economy will respond to change. In an I-O model, the increase in demand for a certain product or service causes a multiplier effect, layers of effect that come in a chain reaction. Increased demand for a product affects the producer of the product, the producer's employees, the producer's suppliers, the supplier's employees, and so on, ultimately generating a total effect in the economy that is greater than the initial change in demand. Say demand for Andersen Windows' wood window products increases. Sales grow, so Andersen has to hire more people, and the company may buy more from local vendors, and those vendors in turn have to hire more people… who in turn buy more groceries. The ratio of that overall effect to the initial change is called a regional multiplier and can be expressed like this:

(Direct Effect + Ripple Effects) / (Direct Effect) = Multiplier

The term "multiplier" can't be used generically, though. Multipliers always express the ratio of overall effect to initial change by one of three measures: output (dollars' worth of production), labor income, or jobs generated. So there are output multipliers, income multipliers, and employment multipliers. In gauging economic effects, one must be careful about which multiplier is being talked about. Users of IMPLAN or of any input-output model have to make the determination of what the initial change in the economy is—that is, whether they want to study a change in production, labor income, or employment. In general, output multipliers range from 1.3 to 1.8. But employment and labor-income multipliers can bounce around a lot more, depending on production and wage-per-worker data for a given industry and geographic region. Multipliers are very industry-sector and region specific.

As for defining those sectors, Leontief identified just 10 back when he first started working on input-output modeling in the 1920s. Today, Minnesota IMPLAN Group differentiates in its software and data sets between 509 sectors that are recognized by the U.S. Department of Commerce. Each sector has a unique output multiplier, because each industry sector has a different pattern of purchases from firms inside and outside of the regional economy. (The output multiplier is in turn used to calculate income and employment multipliers.)

Estimating a multiplier is not the end goal of IMPLAN users. Most wish to estimate other numbers and get the answers to the following questions: How many jobs will this new firm produce? How much will the local economy be affected by this plant closing? What will the effects be of an increase in product demand? Based on those user choices, IMPLAN software constructs "social accounts," which are mathematical representations of economic interactions—the flow of dollars from purchasers to producers within the region. The data in those social accounts will set up the precise equations needed to finally answer those questions users have—about the impact of a new company, a plant closing, or greater product demand—and yield the answers.

Economists typically construct input-output models using aggregated production, employment, and trade data from local, regional, and national sources, such as the U.S. Census Bureau's annual County Business Patterns report, and the U.S. Bureau of Labor Statistics' annual report called Covered Employment and Wages. The IMPLAN database contains county, state, ZIP code, and federal economic statistics which are specialized by region, not estimated from national averages. Minnesota IMPLAN Group has data sets for the entire United States for the years 1990 through 2007. In addition to gathering enormous amounts of data from government sources, the company also estimates some data where they haven't been reported at the level of detail needed (county-level production data, for instance), or where detail is omitted in government reports to protect the confidentiality of individual companies whose data would be easily recognized due to a sparse population of businesses in the area.

IMPLAN's accessibility and ease of use also make it a target of criticism by some economists, who charge that in the wrong hands, the software—or any input-output model—will produce inflated results at best, and at worst, completely ridiculous projections. Anyone can point and click their way to an outcome without fully understanding the economics in which the tool is grounded and without knowing how to look at data sets with a nuanced eye. The IBRC has two analysts that have attended advanced training in the use of the IMPLAN modeling software. The estimates that the IBRC analysts generate are pressure-tested and triple-checked to ensure that they are accurate and reflect the most trustworthy application of the modeling software. In all instances, the most conservative estimation assumptions and procedures are used to produce the IMPLAN results.

Most of the above IMPLAN software description was culled from the magazine article "The Number Machine," *Twin City Business*, February 2008. It can be found online at: http://www.tcbmag.com/features/features/95796p1.aspx.

Sample Survey (CRADA)

A Survey to Measure the Economic Benefits of Technology Transfer—CRADA

The Department of Navy Technology Transfer Office has commissioned the IBRC to measure the economic impacts of technology transfer (T2) on the U.S. economy. You have received this survey because your organization has a T2 agreement with the U.S. Navy. The survey should take about 20 minutes, less, if you have the data handy. Except for your time, there are no risks associated with participating. You do not need to identify yourself as the respondent. If you are unable to provide exact figures in response to a question, please give your best estimate. If you have any questions regarding this survey, please contact Tanya Hall at halltj@indiana.edu or 812-855-5507.

1. Please complete information about the technology involved in the transfer agreement(s):
   a. CRADA number: ______________________________
2. Name of the technology: ______________________________
   a. What is the common name of this technology? ______________________________
   b. In layman's terms, please briefly describe the technology transferred to your organization: ____________
3. Is this same technology involved in another CRADA, PLA, or other T2 agreement? (circle one): YES/NO
   If yes, please list any other CRADA, PLA, and/or LP-CRADA numbers associated with this technology: _____
   ____
4. Is this technology in a perpetual development loop? (please circle one): YES/NO
5. What is the expected total length of time, from start to finish, to develop this technology (in months)? _____
   ____

Part I: Cooperative R&D Agreement (CRADA)

6. Date the CRADA started and ended (mm/dd/yyyy):
   Started: _____ / _____/ _____
   Ended: _____ / _____/ _____
7. At the start of the CRADA, what was the technology readiness level? (please circle one — refer to appendix for definitions)
   1 2 3 4 5 6 7 8 9 n/a
8. At the end of this CRADA, what was (or will be) the technology readiness level?
   1 2 3 4 5 6 7 8 9 n/a
9. What is, or was, the objective of this CRADA? (please check all that apply)
   - ☐ Use of DoD laboratory equipment, material, data and/or personnel
   - ☐ Pure, basic research
   - ☐ Conduct clinical trials
   - ☐ Further develop the technology
   - ☐ Develop a prototype for internal applications
   - ☐ Develop a prototype for Naval applications
   - ☐ Material or component input for a product or service
   - ☐ Access to software, data, or programming code
   - ☐ Other (please explain) ______________________________
10. When you entered into the CRADA, what were the expected outcomes? (please check all that apply)
    - ☐ Develop a patentable invention
    - ☐ Advance research on the technology
    - ☐ Develop/improve a technology process
    - ☐ Publish a paper on research findings
    - ☐ Submit an invention disclosure

- ☐ Increase profits for the company
- ☐ Enter into a patent license agreement
- ☐ Commercialize a product
- ☐ Develop a commercial off-the-shelf product (COTS)
- ☐ Other (please explain) ____________________

11. Would this CRADA's technology create or retain full-time jobs for your organization? (please circle one): YES/NO (if NO, skip to Question 12)
    a. If yes, how many full-time jobs have been, or will be, created or retained? (on an average annual basis) __
    b. Are these jobs permanent positions? (please circle one): YES/NO
    c. Where are these jobs located? (please identify the top three locations below)
        1. Primary state or country ____________________
        2. Secondary state or country ____________________
        3. Other states or countries ____________________
    d. What is the total annual value of their corresponding salaries plus benefits? $ ____________________
12. At peak activity on this CRADA, how many company full-time equivalent employees were dedicated to working on the CRADA's technology? (if CRADA has not yet reached its expected peak, please estimate peak employment)____________________
13. Did your organization experience (or expect to experience) cost-avoidance or savings due to this CRADA's technology? (please circle one): YES/NO (if NO, please skip to Question 14)
    a. If yes, what type of cost-avoidance or savings did your organization experience (or expect to experience in the future) (please check all that apply)
        - ☐ Equipment cost-avoidance or savings
        - ☐ Payroll cost-avoidance or savings
        - ☐ Research cost-avoidance or savings
        - ☐ Material or component input cost savings
        - ☐ None
    b. What was the average annual cost-avoidance or savings that your organization realized from this CRADA's technology? $____________________
14. Did your organization experience (or expect to experience) increased revenue due to this CRADA's technology? (please circle one): YES/NO (if NO, skip to Question 15)
    a. If yes, what was the source of the increased revenues that your organization experienced or expects to experience in the future due to the CRADA's technology? (please check all that apply)
        - ☐ Improving or extending an existing product
        - ☐ Net present value of future cash flows related to increased sales
        - ☐ Other (please describe) ____________________
        - ☐ No value realized or expected
    b. What was the average annual increase in gross revenue that your organization realized from this CRADA's technology? $ ____________________
15. What is your organization's average annual expense, including payroll and material input expenses, associated with this material transfer agreement and its technology over the life of the agreement?
    a. Average total expense: $____________________
    b. Of this expense, what percentage is represented by employee compensation? ____________________ %

Part II. Miscellaneous Questions

16. Are there any plans to continue working with the Department of Navy with this technology? (please circle one) YES/NO
    a. If yes, under what contractual arrangements? (please check all that apply)
        - ☐ CRADA: Cooperative Research and Development Agreement

- ☐ PLA: Patent License Agreement
- ☐ LP-CRADA: Equipment Transfer
- ☐ LP-CRADA: Material Transfer
- ☐ LP-CRADA: Section 1401 First Responder
- ☐ Other (please specify) ______________________________

17. How would you classify your organization?
    - ☐ Private Company
    - ☐ Non-profit engaged in research
    - ☐ State or local government
    - ☐ University or College
    - ☐ Non-profit providing services
    - ☐ Other (please specify)
18. Please state the industry that best describes your company or organization, for example, pharmaceutical manufacturer. ______________________________
19. What Industry code—the North American Industry Classification System (NAICS)— best reflects your company or subsidiary? ______________________________
    NAICS can be found at: http://www.census.gov/eos/www/naics/
20. Is this company a minority-owned (MBE) or women-owned (WBE) business? (please circle one): YES/NO
21. Is this organization a spin-off by a federal employee from a Department of Defense lab? (please circle one): YES/NO
22. Did your organization have previous experience with the Department of Defense? (please circle one): YES/NO
    a. If yes, how has your organization worked with the Department of Defense? (check all that apply)
    - ☐ SBIR: Small Business Innovation Research
    - ☐ PLA: Patent License Agreement
    - ☐ STTR: Small Business Technology Transfer Program
    - ☐ Government Contract
    - ☐ CRADA: Cooperative Research and Development Agreement
    - ☐ Other (please specify ______________________________
23. How would you classify the size of your company? (please check one)
    - ☐ Very small (1 to 9 employees)
    - ☐ Small (10 to 99 employees)
    - ☐ Medium (100 to 499 employees)
    - ☐ Intermediate (500 to 999 employees)
    - ☐ Large (1000 to 4999 employees)
    - ☐ Very large (5000+ employees)
24. Please list the state where the majority (or all) of this technology's employment and R&D is occurring: ______________________________
25. Please list other states where this technology's activity is occurring, if applicable: ______________
26. In the event that IBRC researchers have questions regarding your response, may we contact you? (please circle one): YES/NO
    a. If yes, please provide your contact information and check the best contact method:
    Name: ______________________________
    Phone number: ______________________________
    Email: ______________________________

Thank you for your time and input!

Please return your completed survey to:

Indiana Business Research Center
Kelley School of Business, Indiana University
100 S. College Street, Suite 240
Bloomington, IN 47404

Appendix: Technology Readiness Levels (TRLs)

TRL	Definition	Description
1	Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development (R&D). Examples might include paper studies of a technology's basic properties.
2	Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.
3	Analytical and experimental critical function and/or characteristic proof of concept.	Active R&D is initiated. This includes analytical studies and laboratory studies to validate physically the analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4	Component and/or breadboard validation in a laboratory environment.	Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared with the eventual system. Examples include integration of "ad hoc" hardware in the laboratory.
5	Component and/or breadboard validation in a relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.
6	System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in a simulated operational environment.
7	System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from TRL 6 by requiring demonstration of an actual system prototype in an operational environment (e.g. in an aircraft, in a vehicle, or in space). Examples include testing the prototype in a test bed aircraft.
8	Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9	Actual system proven through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation (OT&E). Examples include using the system under operational mission conditions.

Source: Defense Acquisition Guidebook