
Original Article

Innovate America: The Technology Innovation Program at NIST

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ABSTRACT 9 August 2007, the US Congress established the Technology Innovation Program (TIP) through the America COMPETES Act, a comprehensive strategy to keep the United States, the most innovative nation in the world, competitive by strengthening scientific education and research, improving technological enterprise, attracting the world's best and brightest workers, and providing twenty-first century job training. The new program, TIP, is located at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD (www.nist.gov/tip).

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INTRODUCTION

One of our nation's greatest strengths is its capacity to innovate. It is important to tap this strength and address the significant challenges that we are facing as a nation and as a society. Therefore, on 9 August 2007,

the US Congress established the Technology Innovation Program (TIP) through the America COMPETES Act,¹ a comprehensive strategy to keep the United States, the most innovative nation in the world, competitive by strengthening scientific education and research, improving technological enterprise, attracting the world's best and brightest workers, and providing twenty-first century job training. The new program, TIP, is located at the National Institute of Standards

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and Technology (NIST) in Gaithersburg, MD (www.nist.gov/tip). Founded in 1901, NIST is a non-regulatory federal agency (www.nist.gov) within the US Department of Commerce (www.commerce.gov). NIST's mission is to promote US innovation and industrial competitiveness by advancing measurement science, standards and technology in ways that enhance economic security and improve our quality of life.² As the technical expertise of NIST scientists and engineers cuts across technology areas, it provides TIP staff with broad reviewer resources for evaluating proposals. TIP and NIST have a mutually beneficial relationship as TIP can tap into extensive NIST resources and NIST scientists can benefit from the results of TIP's extramural research.

TIP'S GOALS

The goal of the new program is to help US businesses, institutions of higher education and other organisations – such as national laboratories and non-profit research institutes – support, promote and accelerate innovation in the United States through high-risk, high-reward research in areas of critical national need.³

TIP aims to speed the development of high-risk, high-reward research with a potential for transformational results targeted at key societal challenges that are not being addressed elsewhere. Program funds will support research that has scientific and technical merit, as well as strong potential for advancing the state of the art and contributing to the US science and technology base. Funding will be provided to industry (small and medium-sized businesses), universities and consortia for research and development (R&D) on potentially revolutionary technologies to meet critical national needs. The research will carry high technical risks – and commensurate high rewards if it is successful. The primary funding mechanism for this support is cost-shared financial assistance awards based on merit competitions, and is implemented using cooperative agreements.

KEY TIP CONCEPTS

There are several key concepts that guide the program as ideas for competition topics are gathered and evaluated and when proposals are reviewed for funding:

- An area of *critical national need* means an area that justifies government attention because the magnitude of the problem is large and the societal challenges that need to be overcome are not being addressed, but could be addressed through high-risk, high-reward research.
- A *societal challenge* is a problem or issue confronted by society that, when not addressed, could negatively effect the overall function and quality of life of the nation, and as such justifies government action.
- A *transformational result* is a project outcome that enables disruptive changes over and above current methods and strategies. Transformational results have the potential to radically improve our understanding of systems and technologies, challenging the status quo of research approaches and applications.

SPECIFIC TIP FEATURES

The major features of the TIP are established in the authorising legislation. The following are some highlights:

- *TIP has a novel purpose*: TIP awards funding to high-risk, high-reward R&D projects that address critical national needs and societal challenges in any area that is important to the nation but are not being addressed by others. TIP has the agility to make targeted investments that are within NIST's areas of technical competence and are not currently funded by other mission-oriented agencies or programs.
- *TIP supports rich teaming*: Projects may be proposed by individual for-profit companies or by joint ventures that may include for-profit companies, institutions

of higher education, national laboratories or non-profit research institutes, so long as the lead partner is either a small- or a medium-sized business or an institution of higher education.

- *TIP is a public-private partnership:* TIP makes cost-shared awards of up to 50 per cent of the total project costs. TIP may award funding of direct costs totalling up to US\$3 million over 3 years for a single-company project or up to \$9 million over 5 years for a joint venture.
- *TIP supports small- and medium-sized businesses:* Large businesses may participate in a TIP-funded project, but they may not receive TIP funding.
- *TIP complements – but does not duplicate – existing R&D efforts:* TIP funds R&D that is potentially synergistic with other funded research for which other funding (public or private) is not available, and for which government support is justified.
- *TIP contributes to the US knowledge base:* The title to any intellectual property created through TIP funding will vest with the participating TIP award recipient company or with any joint venture member.
- *TIP is part of the US innovation system:* An external TIP Advisory Board will provide advice on programs, plans, policies, and on the general health of the Program.
- *TIP will assess its progress and results:* TIP will use state-of-the-art evaluation and assessment techniques to ensure optimal performance and results.
- *TIP is part of NIST:* NIST – the US institution for advancing measurement science, standards, and technology – provides the Program with a rich innovation infrastructure consisting of groundbreaking research conducted by world-class physical and biological scientists and engineers.

In responding to critical national needs, TIP intends to realise the potential of the program through the ability to fill strategic gaps that

have often occurred because of limitations on funding priorities and provide synergy within the federally funded research spectrum. The key component of this Program and its eventual legacy will be the proficiency with which TIP is able to leverage high-risk, high-reward technology to meet these societal challenges and solve problems of critical national need.

DEVELOPING AND SELECTING AREAS OF CRITICAL NATIONAL NEED FOR TIP

The TIP statute requires that the funded competitions focus on specific research, or on technology areas and sectors that are important for addressing societal challenges within areas of critical national need.

During its inaugural year, TIP is developing a pipeline of potential critical national need areas using these guiding principles: leverage, consideration of a broad range of potential ideas and the application of defined measures that allow comparison of different topic areas. A set of standard measures were developed, which allowed the TIP Director to systematically evaluate differing areas and challenges and make an investment decision in areas of critical national need and specific associated societal challenges.

To move forward, an area of interest had to address the following three criteria and the underlying questions:

1. *Mapping to the Administration Guidance:* How well do the identified societal challenges fit within the proposed area of critical national need? What existing efforts are addressing these problems, what is the significance of the challenges to the Nation's well-being and how highly regarded are they in the national discussion? Are they identified within national policy reports, special publications or public memos? What levels of support currently exists to address this problem?

2. *Justifying government attention:* What is the magnitude of the problem and what are the specific societal challenges within the area? Does the research to meet those challenges have strong potential for advancing the state of the art and contributing significantly to the US science and technology knowledge base? What is the cost if the challenges go unmet or consequences if solutions are delayed? Why is it important to the nation for the government to be involved?
3. *Describing the essentials for TIP funding:* How will the nation's capabilities be stimulated with this critical national need? What is the technology leverage for success or failure? What is the evidence that the research will not be conducted within a reasonable time period in the absence of TIP funding? Are no other alternative funding sources reasonably available to support the research? How could the research impact the nation in a transformative way? How would success (or partial success) provide dramatic benefits to the nation?

In early 2008, TIP staff studied several public documents from a variety of sources within the government. These included guidance from the White House Office of Science and Technology Policy (OSTP), independent authorities such as the National Academies, and other national efforts such as industry road maps. These resources helped TIP identify potential areas of interest, which included personalised medicine, water, energy, civil infrastructure, manufacturing, complex networks and communication. At the request of TIP, the National Academies of Sciences held a national symposium on 24 April 2008 to further address these areas and pursue additional dialog with industry, universities, states and professional societies.

Based on this additional input and the budget constraints, one topic was selected for the inaugural 2008 competition – ‘Advanced Sensing Technologies for the Infrastructure:

Roads, Highways, Bridges, and Water Systems.’ Several other areas of interest are being studied and evaluated for subsequent competitions. Thus, the focus of future competitions could be in any area – including biosciences and biotechnology research – that has potential to yield transformational results that can address specific societal challenges in areas of critical national need.

TIP CALL FOR WHITE PAPERS

In September 2008, TIP placed a call on its website for white papers from any interested parties, including academia; federal, state and local government; industry; and professional organisations/societies to help TIP shape future competitions and increase its outreach to communities that may be interested in providing input. The white papers are expected to discuss large problems that potentially inhibit the growth and well-being of our nation today and address areas of critical national need. They should include:

- a description of an area of critical national need and the associated societal challenge(s);
- an explanation of how the societal challenge topic area(s) could lead to proposal submissions of high-risk/high-reward research projects;
- a detailed account of how transformational research could meet the identified challenges(s) within an area of critical national need while addressing three major selection criteria highlighted below and described in the previous section:
 - Mapping to administration guidance
 - Justifying government attention
 - Describing the essentials for TIP funding

The white papers need to include only non-proprietary information and discuss problems to be addressed rather than a specific technical solution or individual projects. White papers should define a broad agenda in which many companies and academic or non-profit

institutes would want to participate at a programmatic level. Although the current call has specified 1 December 2008 as the deadline for white paper submissions, additional deadlines in 2009 include 12 January, 9 March, 11 May and 13 July. These white papers, along with the vision of the administration, NIST, other government agencies and key stakeholders will be incorporated into the TIP selection process.

Once TIP selects societal challenge topic area(s) for a competition in an area of critical national need, the competition will be announced in the Federal Register and as a Federal Funding Opportunity Notice in Grants.gov, along with publication of a proposal preparation kit and a white paper on the selected critical national need topic(s).⁴

POTENTIAL CRITICAL NATIONAL NEED AREAS AND BIOTECHNOLOGY

Biotechnology can be defined as any technological application that involves methods and techniques using living organisms (for example, cells, bacteria, yeast) or their parts or products.⁵ Biotechnology provides the tools for developing applications in diverse fields such as medicine, agriculture and biomanufacturing (for example, biofuels, plastics, vaccines), and includes a wide range of techniques for modifying biological organisms as per the needs. Biotechnology combines several disciplines such as genetics, molecular biology, biochemistry and cell biology with disciplines like chemical engineering, robotics and information technology. TIP continues to examine diverse areas of critical national need and is interested in developing a pipeline for subsequent competitions. Several of these may involve biotechnology solutions for addressing societal challenges. Evaluation of any area includes close coordination between TIP and its sister mission agencies to make sure that TIP competitions are not duplicative but are complementary to the current funding opportunities within other federal agencies.

Therefore, TIP is very interested in what other agencies see as opportunities for TIP that could leverage the mission agency's efforts in new and promising ways.

One of the initial areas of interest identified by TIP is personalised medicine. Potential topics include novel tools and technologies for drug delivery systems, proteomics, biomarker identification, or biological data integration and analysis. TIP is also exploring other areas that may involve biotechnology, including tools and techniques for cost-effective, sustainable, and renewable feedstocks for biofuels and plastics, sensors for ensuring water and food security, and scale-up techniques for nano- and biomanufacturing. The white papers submitted to TIP in biotechnology and other areas may play a critical role in shaping TIP competitions in the coming years.

DIFFERENCES FROM THE PREVIOUS ADVANCED TECHNOLOGY PROGRAM (ATP) AT NIST

In 1990 the US Congress established at NIST the ATP as a rigorously competitive cost-shared program. The goal of ATP was to assist the US industry in developing innovative and high-risk technologies with a potential for broad-based national benefits. The America COMPETES Act of 9 August 2007 terminated this program. TIP was charged with continued management of on-going projects previously funded under ATP.

The most important distinction between this previous NIST program and the newly initiated TIP program is that TIP has a *significantly different mission*. Research projects funded by the ATP had a general requirement to demonstrate that they were 'high risk' – that is, the research was technically challenging and success would require a major advance over the state of the art – *and* that the target technology had at least the potential to bring significant economic benefits to the nation through one means or another. TIP also has the 'high-risk' element, but it is

somewhat more expansive as the ‘high-risk, high-reward’ element. This takes into account a broader scope of high reward to include impacts that have key benefits to the nation, without being strictly economic benefits. In addition, TIP is more tightly concerned with technologies that address ‘areas of critical national need’ that justify government action. TIP is interested in solutions to meeting important societal challenges – but solutions that could impact either how research is accomplished or the marketplace, or both.

TIP also has somewhat different eligibility, project structure, funding and cost-share requirements.

ELIGIBILITY

Under ATP, funding could go to single, for-profit US companies or to industry-led ‘joint ventures’ of two or more for-profit companies, which also could include non-profit research institutions, universities or federal laboratories other than NIST. There were also restrictions on the amount of funding that could go to a large company (defined as having a revenue greater than or equivalent to the 500th member of the ‘Fortune 500’) in a single-company award, and the lead partner in a joint venture had to be a company or a non-profit research institution, not a university or federal lab. Intellectual property created as a result of the project had to be held by one or more for-profit companies incorporated in the US.

Under TIP, funding can go to a single company project led by a small- or medium-sized company (large companies are excluded) or to a joint venture, with the important differences that institutions of higher education can be the lead partner in the joint venture, and the resulting intellectual property may reside with any member of the joint venture, including universities and non-profit research institutions. Large companies (defined as having a revenue greater than or equivalent to the 1000th member of the ‘Fortune 1000’) may participate in a TIP joint venture, but they may not receive federal funds.

FUNDING

The ATP could fund single-company projects for no more than \$2 million total over a period of no more than three years, and ATP funds were limited to direct costs only. Under ATP, single-company projects were required to cover all their indirect costs, and were not required to cost share the direct costs. Joint-venture projects could be funded for no more than five years, but there was no limit to the size of the award other than the amount of available funds, and the requirement to meet greater than 50 per cent cost share of total project costs. (ATP funds could pay for direct and indirect costs in a joint venture.)

As mentioned, TIP can fund single-company projects for up to \$3 million over three years, and joint ventures for up to \$9 million over five years. There are a few additional differences between the two programs, particularly related to the rules on matching funds. TIP will fund no more than 50 per cent of the total project costs (direct plus indirect costs), but TIP funds may be used only for direct costs, not indirect costs (such as overhead or management fees) in either type of award. No TIP funding may go to a large company. TIP is, however, authorised to continue funding and managing projects that were begun by ATP under the terms of the original ATP awards.

ACCOMPLISHMENTS OF THE ATP-FUNDED PROJECTS IN BIOTECHNOLOGY

Since its inception in 1990 and during the 44 competitions that were held between 1990 and 2004, 768 ATP projects were selected, of which 224 projects (30 per cent) and \$620 million of federal funds involved biotechnology and or healthcare-related technologies. A pie chart of these awards is shown in Figure 1.

The ATP-funded projects in biotechnology contributed significantly to the US technology base. For example, the January 2007 ATP report on ‘Economic Impact of ATP’s Contributions to DNA Diagnostics Technologies’⁶ discussed the contributions of

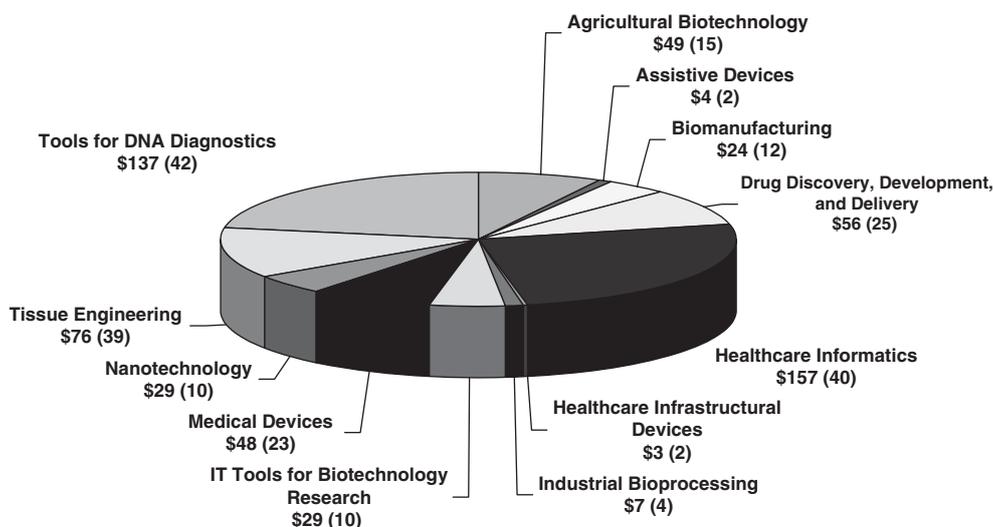


Figure 1: ATP awards in biotechnology and healthcare in \$millions (#projects).

several DNA diagnostics projects. A project by Affymetrix led to advancements in microarray design and manufacture, sample labelling and assay protocols, as well as in the software used to analyse the data input. The project accelerated the development of process technologies that made microarray production more efficient and increased the analytical capability of the chips four-fold while simultaneously increasing their quality. A project by Molecular Diagnostics led to the first high-throughput capillary array DNA sequencer, induced innovation at its main competitor, Applied Biosystems, and accelerated the Human Genome Project and other high-throughput genomics projects. Additionally, Third Wave Technologies, Inc. developed easy-to-use genetic analysis test kits that could quickly identify the presence of genetic markers for several inherited and infectious diseases. Inexpensive diagnostic tests developed by Third Wave were used to complete 250 per cent of the International HapMap project.⁷

In the areas other than DNA diagnostics technologies, Aastrom Biosciences developed a desktop-size bioreactor to produce large amounts of stem cells and other cells from the bone marrow, umbilical cord blood and

possibly other human tissues.⁸ Revivicor, Inc. developed genetically altered pigs, with a specific gene inactivated, which prevents hyperacute rejection of transplanted tissue.⁹

We hope that the impact of the newly created TIP program is equally exciting and could yield even more significant results in the future for US technology.

SUMMARY

These are very exciting times technologically as new discoveries proliferate. TIP projects can leverage and combine those discoveries into useful tools that address problems of critical national need. As the US faces major challenges internally and externally, TIP is prepared to be at the forefront in the development of solutions that improve the way America competes. Despite the challenge of implementing a new program in a short period, much has been accomplished in TIP's inaugural year. In the past 12 months, the Program has completed the initial organisation of staff and offices, published the Program Rule,¹⁰ developed internal administrative processes, created the critical national need identification and selection processes, published a proposal preparation kit, conducted a competition and made awards.

The unprecedented speed with which TIP accomplished these tasks is due to the tireless efforts of the highly competent and highly motivated TIP staff. Continued efforts to identify more areas for competitions are ongoing and will fuel further funding efforts. As more white papers are developed and received from the science and technology communities, they will enhance TIP's ability to identify new areas and expand the program in the coming years.

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NON-DISCLAIMER

Certain companies and projects are identified in this article for completeness. In no instance does this identification imply a recommendation or endorsement by the

National Institute of Standards and Technology, nor does it imply that the companies and the projects identified are necessarily the best ones for this purpose.

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