The Economic and Programmatic Impacts of the Maryland Technology Development Corporation on the Maryland Economy

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EXECUTIVE SUMMARY

Innovation stands as a leading competitive factor driving economic growth for states and regions in today's global, knowledge-based economy. According to the recently released National Research Council Report, *Rising to the Challenge*, the capacity to innovate is fast becoming the most important determinant of a region's economic growth and its ability to compete and prosper in the 21st century global economy.[1] Even back at the turn of the century, the importance of innovation was becoming clear. The former Chairman and CEO of IBM, Samuel Palmisano, explained the challenge broadly to the U.S.: "A key determinant of growth is innovation. Where, how and why innovation happens is changing. If the U.S. wants its fair share of new jobs and economic growth, it must take the steps necessary to continue offering the most fertile, attractive environments for innovation in the world."[2]

The specific challenge in innovation confronting Maryland is well documented. Maryland is a recognized international leader in research and development—with major research universities and the nation's most advanced complex of federal laboratories. But Maryland has been less successful in terms of the transformation of its research and development strengths into new products, high-growth companies and jobs. According to the Information Technology and Innovation Foundation in its State New Economy Index, Maryland's high ranking as a technology state is "primarily due to high concentrations of knowledge workers, many employed with the federal government or related contractors in the suburbs of Washington, D.C." While this has been good for the Maryland economy, strong reliance on federal spending bodes poorly for the future in an era of federal downsizing and sequestration. Indeed, Maryland lags in the commercialization of technologies based on its large base of university and federal research. The Milken State Science and Technology Report finds that despite Maryland's strength in research and development and high concentration of high technology workers, the state's weakest areas are access to risk capital and entrepreneurial success**.**

The creation of the Maryland Technology Development Corporation (TEDCO) was the state's response to addressing this challenge of fostering greater innovation for today's global, knowledge-based economy. TEDCO was created by the Maryland State Legislature in 1998 to facilitate the transfer and commercialization of technology from Maryland's research universities and federal labs into the marketplace resulting in the creation and growth of technology-based businesses in all regions of the state.

TEDCO's efforts are generating a strong economic impact. An independent assessment by the Battelle Technology Partnership Practice, the economic development consulting group of the world's largest independent research and development non-profit, further found significant economic impacts from TEDCO's activities:

- *The economic contribution to the Maryland economy of TEDCO's three core research, technology transfer and commercialization programs totaled $565.9 million in 2013, generating a total of 2,835 jobs.*
- *TEDCO's efforts are also generating high quality jobs with average compensation per job created estimated at $70,700 compared to statewide average private sector job compensation of $59,000.*

[1] Charles W. Wessner and Alan Wm. Wolff, Eds. "Rising to the Challenge: U.S. Innovation Policy for the Global Economy". 2012. The National Academies Press, Washington, DC., page xiii

[2] Samuel J. Palmisano, "How the U.S. Can Keep Its Innovation Edge," *BusinessWeek*, November 17, 2003, page 34

- *Estimated state and local government revenues from the economic activity attributable to TEDCO activities reached $22.8 million in 2013—a level of revenues that represent 120 percent of TEDCO's FY2013 appropriation of $19 million.*
- *Battelle calculated an estimated 23 percent return on investment for 2013 on the State of Maryland's investment in TEDCO's core commercialization and technology support programs.*

Most importantly, the impact of these existing TEDCO efforts is projected to grow substantially over the next decade. Battelle estimates that the economic impacts associated with TEDCO's two core technology transfer and commercialization programs, the Technology Commercialization Fund (TCF) and the Maryland Innovation Initiative (MII), and the Maryland Stem Cell Research Fund (MSCRF) will grow to $910.3 million in 2018, support a total of 4,527 jobs earning $320.3 million, and generate estimated state and local government revenues of $36.6 million, a 68 percent increase over TEDCO's current economic impact, based on current funding and outcomes levels. These ever-rising impacts from TEDCO's investments are not surprising, and reflect the fact that TEDCO's efforts play a key role in early-stage venture development, which will continue to have a positive economic impact for as long as those new ventures continue to operate. This type of activity generates a significant pay-off in sustaining future economic growth.

Beyond its overall economic impact, TEDCO plays a critical role in facilitating, supporting, and enhancing the generation, transfer and commercialization of technologies in Maryland. Altogether, TEDCO's technology transfer and commercialization programs have resulted in investments in a portfolio of 216 start-up and early-stage companies, which have: attracted an additional $601 million in downstream investment, thereby matching each state dollar invested by TEDCO with over $48 in additional, outside investment; supported the creation of 58 new start-up companies; and generated 45 technology licenses for universities and federal laboratories in Maryland.

In advancing these broader functional benefits in supporting Maryland's economy, Battelle notes the following:

- **TEDCO's programs can be viewed as an investment in a portfolio of companies and research**. The economic impacts of TEDCO represent more than a simple source of spending. Unlike many other state government efforts, TEDCO's client firms often leverage the initial state funding with additional private capital, in the case of its core commercialization and technology support programs and with additional federal or private research funding, in the case of the Maryland Stem Cell Research Fund. Furthermore, the portfolio of companies created, and in many cases the stem cell research projects initiated, both remain active in Maryland even after the initial period of state funding, and the state can capture any benefits associated with the growth of its portfolio companies supported and technologies commercialized from the stem cell research funded. Thus, TEDCO programs have the potential to create a portfolio of companies and research activity that both leverage the initial state investment with outside dollars and continue on after the initial period of state funding ends.
- **In its stem cell research program activities, TEDCO's early-stage funding for university researchers has helped raise Maryland's national leadership position**. From 2009 to 2012, Maryland raised its level of NIH funding support from $40.3 million to $114.4 million, resulting in its significantly improved standing in this highly competitive research field from eighth in the nation to third in the nation for NIH funding of stem cell research.

- **TEDCO has achieved these results in a cost effective manner,** and has achieved both a rate of return and level of job creation comparable to similar state technology-based economic development organizations that enjoy much higher levels of funding.
- **TEDCO's success demonstrates the value of a public-private partnership effort**. TEDCO operates as a public corporation authorized and funded by the state, with strong engagement and leverage of private sector resources. This unique operating model allows TEDCO to act in an independent, flexible, and nimble manner and contributes to the success of the organization.

Looking forward, Maryland needs to consider how to invest in sustaining and accelerating its economic growth in the years ahead. Continued federal downsizing will challenge Maryland to maintain its past levels of economic growth and prosperity. In the context of slow growth in federal government spending, Maryland will need to diversify its economy and more successfully capitalize on its technology assets.

- **Innovation will be a key to ensuring Maryland's economic future**. As the 2011 five-year economic development strategic plan put forth by the industry-led Maryland Economic Development Commission, *Charting Maryland's Economic Path: Discovery, Diversity & Opportunity: A Five Year Strategic Plan*, there needs to be a focused effort to "reinvigorate and bring critical mass to Maryland's commercialization resources."[3]
- **TEDCO is a proven entity that can be further scaled up to address the size of the opportunity for advancing innovation in Maryland.** The creation of the InvestMaryland program, and renewed emphasis of technology transfer, commercialization and job creation at the University System of Maryland, makes TEDCO's commercialization assistance programs and pipeline of early-stage companies vitally important to supporting overall state economic development goals. At the same time, there is a substantial unmet need for TEDCO's core programs, with only 29 percent of MSCRF, 37 percent of TCF and 40 percent of MII applications funded over the entire history of each program and its predecessors. This point is even more critical given that TEDCO is often the only source of funding for these seed/early-stage companies, which often become candidates for financing from the Maryland Venture Fund and other InvestMaryland funds, in which the state has made significant investments.

Approach to Measuring TEDCO's Record of Achievement

TEDCO plays the lead role in Maryland's efforts to expand commercialization and is involved in all stages of the commercialization process, from supporting research, to facilitating technology transfer, to supporting entrepreneurship, to investing in companies. TEDCO's mission of supporting technology development and commercialization gives the corporation a clear and vitally important role in Maryland's economic development efforts and the state's entrepreneurial ecosystem. In order to describe its important contributions to Maryland, TEDCO contracted with the non-profit Battelle Technology Partnership Practice (TPP) to prepare an analysis of the economic and functional benefits of its operations.

Battelle is the world's largest non-profit independent R&D institution, and the Battelle TPP is the leading national provider of advanced impact analysis and economic development consulting services for state governments, regional economic development organizations, and major research universities and institutions. The program staff at the TPP has considerable experience in evaluating the impact of investments in technology-based economic development at the national, state, and regional levels.

[3] http://www.governor.maryland.gov/documents/MEDCreport.pdf.

The Battelle TPP's approach in analyzing the economic and functional benefits of TEDCO's operations combined a ***quantitative analysis*** of the economic impacts of TEDCO's three core research and technology transfer and commercialization programs, the *Maryland Stem Cell Research Fund* program, *Technology Commercialization Fund*, and the *Maryland Innovation Initiative,* with a ***qualitative assessment*** of the role and contribution of TEDCO's overall operations to Maryland's economic development efforts and technology and entrepreneurial ecosystem. The analysis prepared by Battelle for TEDCO consists of the following components:

- Input/output (I/O) analysis to measure the direct, indirect, and induced economic impacts of TEDCO's three core research and technology transfer and commercialization programs on the Maryland economy. This quantitative analysis estimates the economic contribution of these three programs on Maryland employment, labor income, business volume (economic output), and state and local government revenues.
- A qualitative assessment, called the functional impact, of the role and importance of these three programs as well as TEDCO's mentoring and other technology and business support programs to facilitating Maryland's technology and entrepreneurial ecosystem.
- A comparison of the results of this analysis of TEDCO's economic and functional impacts TEDCO to existing evaluation materials for similar state Technology-Based Economic Development (TBED) programs.

Sizable Economic Impacts Found from TEDCO's Core Research and Technology Deployment Programs

TEDCO's three core research and technology transfer and commercialization each have an economic impact on the Maryland economy. Battelle analyzes the economic contribution of technology-based economic development programs in terms of their impact in two core areas:

- **Research and Development (R&D) Expenditures** – TBED organizations support university, business, and other types of research and development expenditures. These expenditures have economic impacts as they are circulated in a regional economy.
- **Business Activities** – TBED organizations provide programs to: 1) foster entrepreneurship and the commercialization of new technologies; and 2) meet the capital needs of entrepreneurial and technology-based businesses. These programs create a "portfolio" of businesses assisted by state or local TBED programs. The operations of these businesses created or assisted and the product sales related to technologies commercialized represent the core economic impacts associated with TBED programs.

The research expenditures and business activity supported by TBED programs have multiplier effects across Maryland's economy. In order to conduct research, universities, federal laboratories, and business R&D facilities purchase goods and services from local suppliers and employ local residents. Similarly, technology-based businesses purchase goods and services from local suppliers and pay salaries to local workers. These purchases and wages are circulated in the regional economy to other businesses and workers who in-turn purchase goods and services from other local companies, who employ and pay wages and salaries to other workers through successive cycles of revenues and purchases. As a result, the total economic activity supported by TBED programs is greater than their simple R&D expenditures or portfolio company revenues and jobs created. This additional increment of economic activity is called the "multiplier effect."

As presented in Table ES-1, the economic contribution to the Maryland economy of the research and business activities associated with TEDCO's three core programs totaled $565.9 million in FY2013, with

a total of 2,835 jobs earning $200.5 million supported, and estimated state and local government revenues of $22.8 million. It is important to note that the economic activity associated with TEDCO's portfolio of companies assisted and research programs generated combined state and local tax revenues that exceeded its state appropriation of $19 million. The research activities funded by TEDCO and the portfolio of companies assisted by TEDCO directly contributed $335.4 million in business activity and supported 1,225 jobs. These were augmented with an additional $111.1 million in economic activity and 719 jobs supported by the *Indirect Effects* or local purchases associated with TEDCO's operational impacts, and a further $119.3 million and 891 jobs supported by the *Induced Effects* from the increase in local incomes attributable to these activities.

Table ES-1: Economic Contribution of TEDCO's Three Core Programs on the Maryland Economy

	Output ($s)	Labor Income ($s)	Employment	State/Local Tax Revenue ($s)	Federal Tax Revenue ($s)
Direct Effect	$335,432,555	$112,816,364	1,225	$8,677,640	$20,773,223
Indirect Impacts	$111,123,719	$46,324,663	719	$5,727,694	$9,044,938
Induced Impacts	$119,316,619	$41,321,875	891	$8,347,312	$9,036,140
Total Impact	**$565,872,893**	**$200,462,902**	**2,835**	**$22,752,646**	**$38,854,301**
State Impact Multiplier	1.69	1.78	2.31		

Source: Battelle calculations using IMPLAN I/O modeling

The total impacts associated with TEDCO's three core programs are presented in Table ES-2, with the contribution of each program as follows:

- The portfolio of companies associated with the *Technology Commercialization Fund* has total direct employment of 1,147 jobs and estimated direct annual revenues of $321.3 million.[4] The business activities of these TEDCO-supported businesses generate $539.6 million in economic activity in Maryland, support 2,666 jobs earning $188.7 million, and have an associated $21.7 million in estimated state and local government revenues.
- The portfolio of 33 FY2013 company technology commercialization projects associated with the *Maryland Innovation Initiative* had total direct expenditures of $3.4 million. Because this program was started in the middle of FY2013, no outcomes data in terms of jobs created or product revenues were yet available. As a result, the economic contribution of this program was estimated based on the commercialization-related expenditures of the projects funded. The technology commercialization related expenditures of the Maryland Innovation Initiative are estimated to directly create 19 jobs, and when multiplier effects are included, to generate $6.4 million in economic activity in Maryland, support 41 jobs earning $2.8 million, and have an associated $0.3 million in estimated state and local government revenues.
- The $10.7 million in R&D activities associated with the *Maryland Stem Cell Research Fund* are estimated to directly create 59 jobs. When multiplier effects are included, the Maryland Stem Cell Research Fund generates $19.9 million in economic activity in Maryland, supports 128 jobs earning $8.9 million, and has an associated $0.8 million in estimated state and local government revenues;

[4] As described below, TEDCO provided a database of 216 TCF companies and available outcomes measures. This data was supplemented with Battelle research to estimate total portfolio employment. Because few companies reported revenues, the revenue figures used here were estimated based on reported employment by the IMPLAN model.

Table ES-2: Economic Contribution of TEDCO's Three Core Programs on the Maryland Economy by Program

	Output ($s)	Labor Income ($s)	Employment	State/Local Tax Revenue ($s)	Federal Tax Revenue ($s)
Technology Commercialization Fund	$539,622,036	$188,747,177	2,666	$21,661,998	$37,388,155
Maryland Innovation Initiative	$6,356,488	$2,836,893	41	$264,094	$528,699
Maryland Stem Cell Research Fund	$19,894,369	$8,878,832	128	$826,554	$937,447
Total Impact	**$565,872,893**	**$200,462,902**	**2,835**	**$22,752,646**	**$38,854,301**

Source: Battelle calculations using IMPLAN I/O modeling

Functional and Strategic Impacts of TEDCO's Operations

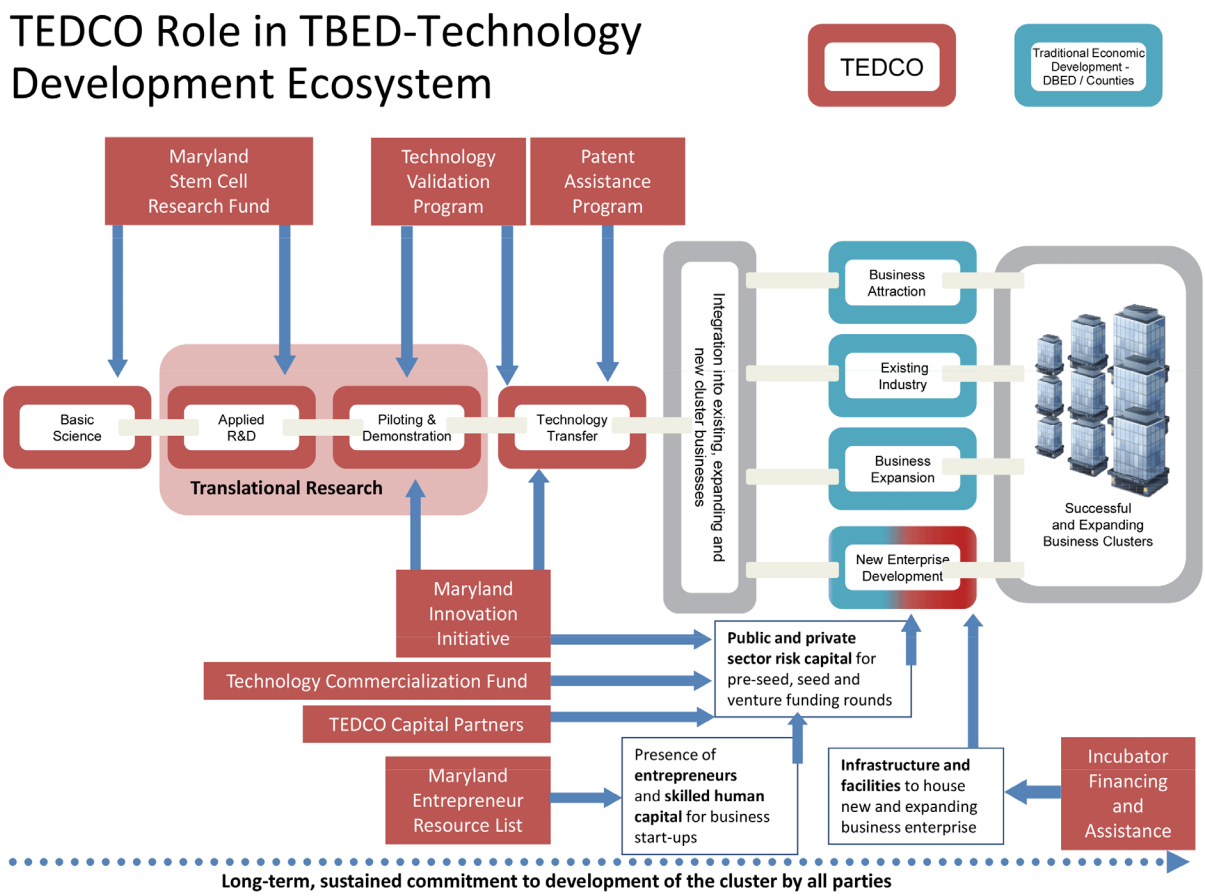
While the economic contributions of TEDCO's three core programs described above are impressive, that represents only a small part of the total impact on Maryland. TEDCO's mission is to support economic development in Maryland by facilitating the development, transfer, and deployment of technologies developed by Maryland's public, private, and government research institutions. Its core mission is to enhance Maryland's "technology and entrepreneurial development ecosystem." In many ways, TEDCO's strategic and programmatic efforts to expand technology development and commercialization are far more important than the economic and job creation impacts described above.

While the strategic and functional impacts of TEDCO on economic and technology development in Maryland are critically important, it is quite difficult to measure and quantify these impacts. Functional impacts, also known to economists as forward linkage impacts, are the critically important effects on the economic ecosystem generated by the technology commercialization programs and services provided by TEDCO. Some aspects such as research volume, companies mentored, and technologies licensed or patented can be quantified. However, assigning an economic value to these programs, projects, or interventions is difficult, if not impossible. As a result, Battelle has focused its efforts on describing the role of and need for the TEDCO programs offered along with any available performance metrics.

Battelle's analysis of the functional and strategic value of TEDCO is grounded on its national and international work on supporting technology-based economic development at the county, regional, state, and even national level. Achieving success in technology-based economic development is a particularly complex and challenging goal. It requires having in place an interconnected value chain of economic development resources and services to develop and sustain growth across research discoveries and technology commercialization, new enterprise development, growth of existing industry, and attraction of new businesses. If any link in the chain is missing, knowledge-based economic gains in growth-oriented new and existing companies and high-quality job creation are hampered.

In order to analyze the functional and strategic importance of TEDCO in Maryland's technology and entrepreneurial development ecosystem, Battelle analyzed the role of TEDCO's programs at each link in the TBED Development Process. An overview of this analysis is presented in Figure ES-1.

Figure ES-1: TEDCO's Role in the Technology-Based Economic Development Process



As described in Figure ES-1, TEDCO provides a full menu of programs designed to support and facilitate the generation, transfer and commercialization of technology in Maryland. Not only does TEDCO generate the economic impacts described above, it provides a full range of services to address the "commercialization gap" identified in both the *Charting Maryland's Economic Path: Discovery, Diversity & Opportunity: A Five Year Strategic Plan* economic development strategy prepared by the Maryland Economic Development Commission as well as in national reports on technology-based economic development in Maryland as hindering economic development in Maryland. TEDCO's programs provide needed financial and technical assistance along each of the key links in the TBED Economic Development Value Chain and provide financial and technical support in the critical "Valley of Death" that hinders commercialization. By numerous measures, TEDCO has been successful in these efforts:

- The Maryland Stem Cell Research Program has improved Maryland's national footprint in this important area of life sciences research and development—and contributed to Maryland moving from eighth in NIH funding for stem cell research to third in the nation.
- The Maryland Innovation Initiative and Technology Validation Program support the early-stage capital needs of entrepreneurial ventures seeking to commercialize the new technologies being discovered in Maryland's leading universities and federal laboratories. Its predecessor

programs, the University Technology Development Fund (UTDF) and TechStart, assisted 72 technology licenses and supported the creation of 58 new start-up companies.

- The Technology Commercialization Fund has created a portfolio of 216 successful companies that have gone on to receive $601 million in downstream funding to further support their commercialization efforts, more than ten times the level of state funding for the program.
- The Rural Business Innovation Initiative (RBI2), Maryland Entrepreneurs Resource List (MERL) and Incubator Business Assistance Fund all provide access to technical support and assistance to support entrepreneurial development in Maryland.
- TEDCO Capital Partners assists in addressing the shortage of venture capital investment in the state.

Through these programs and efforts, TEDCO makes a clear and important contribution to improving the technology and entrepreneurial development ecosystem in Maryland. TEDCO's mission and programs are central to the State of Maryland's economic development strategy and consistent with national state technology-based development best practices.

INTRODUCTION

TEDCO's Mission and Selected Performance Metrics

TEDCO was created by the Maryland State Legislature in 1998 to facilitate the transfer and commercialization of technology from Maryland's research universities and federal labs into the marketplace and to assist in the creation and growth of technology-based businesses in all regions of the state. TEDCO serves as the hub of Maryland's entrepreneurial network where start-ups find mentors, organizational assistance, facilities for daily operations, and a roadmap for success.

TEDCO provides the following services:

- Establishes and manages programs that support innovation, entrepreneurship, and business incubation;
- Provides funding to support technology transfer, product development, and business creation;
- Makes pre-seed investments in start-up and early-stage companies to better position them for follow-on investment; and
- Supports university and private sector translational and stem cell research.

Since its founding, TEDCO has deployed $154 million for innovation in almost 500 projects across all of its programs. Some recent TEDCO accomplishments through the end of fiscal 2013 include the following:

- TEDCO launched the Maryland Innovation Initiative (MII), a $5.8 million annual program to enhance and expand technology transfer at the following five Maryland universities: Johns Hopkins University; Morgan State University; University of Maryland College Park; University of Maryland Baltimore County; and University of Maryland Baltimore. TEDCO received 89 MII applications and funded 33 projects in its first year of operation.

- TEDCO continued to serve Maryland entrepreneurs, with over 500 entrepreneurs attending the TEDCO Entrepreneur Expo and 85 mentors providing service to numerous companies through the Maryland Entrepreneur Resources List (MERL). TEDCO also supported the Venture for America program to place talent in early-stage companies.

- Through the Maryland Stem Cell Research Fund (MSCRF), TEDCO funded $10.4 million in 31 new projects. It also hosted its annual symposium this year in Baltimore, with over 350 participants.

TEDCO's core service delivery programs reported the following overall lifetime impacts:

- The Technology Commercialization Fund (TCF) has awarded more than $12.5 million in project funding for 229 projects to 210 companies that have received $601 million in follow-on funding to further develop the TEDCO-assisted technologies. For each $1 in state funding that TEDCO has invested in these companies, they have gone on to secure, on average, over $48 in additional follow-on funding from other investors.

- The Technology Validation Program and its predecessors, the University Technology Development Fund (UTDF) and TechStart programs, have awarded $6 million to Maryland researchers, an investment that has resulted in 45 technology licenses and 58 start-up companies created from TEDCO research programs.

- The Rural Business Innovation Initiative (RBI2) has served 597 rural businesses, with 423 receiving mentoring.
- The Maryland Stem Cell Research Fund (MSCRF) has awarded $100.5 million in 294 translational research grants.

It is clear from these program highlights and outcome measures that TEDCO has played and continues to play a critically important role in Maryland's economic development efforts and its entrepreneurial and technology development ecosystem. To more rigorously document the impacts of these program activities within the context of Maryland's economy, TEDCO retained the Battelle Technology Partnership Practice (TPP). Battelle is the world's largest independent non-profit R&D organization, and TPP is Battelle's technology-based economic development consulting group, with a national standing in evaluating the impact of state and regional technology-based economic development programs.

The Battelle Assessment Approach: Going Beyond Standard Economic Multiplier Analysis to Consider Broader Catalytic or Functional Impacts of TEDCO's Programs

The Battelle TPP approach considers the economic contribution of TEDCO's programs in terms of their impact in two core areas:

- **Research and Development (R&D) Expenditures** – Technology-based economic development organizations support university, business, and other types of research and development expenditures. These expenditures have economic impacts as they are circulated in a regional economy.
- **Business Activities** – Technology-based economic development organizations provide programs to (1) foster entrepreneurship and the commercialization of new technologies, and (2) meet the capital needs of entrepreneurial and technology-based businesses. These programs create a "portfolio" of businesses assisted by state or local technology-based economic development programs. The operations of businesses created or assisted, and the product sales related to technologies commercialized, represent the economic impacts associated with technology-based economic development programs.

One standard technique for measuring the economic impact of this activity is to consider the successive cycles of revenues and purchases made based on the direct expenditures associated with the activity, event, or industry being studied. These purchases and wages are circulated in the regional economy in the form of purchases made from other businesses and wages paid to workers, who in turn purchase other goods and services from other local companies, who employ and pay wages and salaries to other workers through successive cycles of revenues and purchases. As a result, the total economic activity supported by these purchases is greater than their simple expenditures and include these additional rounds of spending, which are called multiplier effects. In essence, this traditional method for analyzing economic impact focuses on the backward linkages that spending has across the economy.

But technology-based economic development goes beyond simply having traditional economic impact multiplier effects. By its very nature, technology-based economic development programs serve as catalysts for further economic growth. As the State Science and Technology Institute explains in its Resource Guide for Technology-based Economic Development, the three major outputs from technology-based economic development are the advancement of a state's or region's (1) intellectual infrastructure, (2) capital, and (3)entrepreneurial culture.[5] The catalytic nature of technology-based economic

[5] http://www.ssti.org/Publications/Onlinepubs/resource_guide.pdf.

development is demonstrated by the fact that spending on research activities and business activities are highly inter-related, with research expenditures helping to generate the technology breakthroughs that business activity spending helps to commercialize.

To capture these broader catalytic aspects of TEDCO's programs, functional impacts from the following activities are also considered:

1. **Investing in R&D and Technology Deployment**: generating technology through R&D and deploying that technology through technology commercialization efforts;
2. **Fostering Entrepreneurship**: supporting the efforts of individual entrepreneurs, reducing barriers to entrepreneurial activity in general and expanding the business and entrepreneurial skills available to new ventures; and
3. **Increasing Capital Access**: working to expand the level of financial investment and business lending available to local technology businesses.

These functional impacts, also known to economists as forward linkage impacts, are the critically important impacts generated by the technology development and deployment programs provided by TEDCO. These include the role and importance of TEDCO's programs in Maryland's economic development efforts and the contribution of these programs to improving Maryland's technology and entrepreneurial development ecosystem. It is the delivery of these programs and services that are at the core of TEDCO's mission and, as will be shown later in this report, the forward linkage functional/strategic impacts of TEDCO are many and have a substantial impact on Maryland's economic development and technology and entrepreneurial development ecosystem. Functional impacts are a challenge to quantify. Some aspects such as research volume, companies mentored, and technologies licensed or patented can be quantified. However, assigning an economic value to these programs, projects or interventions is difficult, if not impossible. As a result, Battelle has focused its efforts on describing the need for the TEDCO programs offered along with any available performance metrics.

It is only through bringing together the economic multiplier impacts and functional impacts that a complete assessment of the value of TEDCO's program activities can be made on advancing Maryland's technology-based economic development.

In the following sections, Battelle sets out its full analysis of the economic and functional impacts generated by TEDCO in Maryland. The analysis provided by Battelle incorporates the following:

- The use of input/output (I/O) analysis to measure the direct, indirect, and induced economic impacts of three of TEDCO's core programs on the Maryland economy: the *Technology Commercialization Fund* and the *Maryland Innovation Initiative*, its core technology transfer and commercialization programs, and the *Maryland Stem Cell Research Fund*;
- Projections of economic future impacts based on TEDCO's past experience;
- An analysis of the functional impact and strategic importance of these three core TEDCO programs in supporting technology commercialization and economic development in Maryland; and
- Benchmarks of TEDCO's impact and importance compared to similar technology-based economic development programs, where evaluation materials were available.

ECONOMIC MULTIPLIER IMPACTS OF TEDCO'S THREE CORE PROGRAMS

Methodology

Battelle has developed and is utilizing a model for assessing the economic contribution of technology-based economic development programs in this analysis of the economic impacts associated with three of TEDCO's core programs on the Maryland economy. These programs are: the *Technology Commercialization Fund* and the *Maryland Innovation Initiative*, its core technology transfer and commercialization programs, and the *Maryland Stem Cell Research Fund.*

The standard analytical technique for the quantification of backward linkage economic impacts is input/output analysis. I/O analysis uses a matrix representation of an economy that quantifies the impact of spending by one sector of the economy on all other sectors, on consumers, and on the government. Battelle uses the Minnesota IMPLAN Group's software and data systems for application of I/O analysis. The I/O methodology allows Battelle to calculate the backward linkage impacts of TEDCO's outcomes across four main measures:

- ***Output***, also known as business volume, is the total value of goods and services produced in the economy from TEDCO's core programs, and represents the typical measure expressed as "economic impact" in a standard economic impact study;
- ***Labor Income*** is the total amount of income, including salaries, wages and benefits, received by workers in the economy as a result of TEDCO's core programs, both directly through research-related and portfolio company payrolls, and induced through the multiplier effect within the economy;
- ***Employment*** includes both direct employment of TEDCO funded research or assisted companies, as well as the jobs within the economy supported by TEDCO-supported business volume (indirect employment); and
- ***Government Revenues*** includes the estimated revenues of both state and local governments and the federal government from all sources as a result of TEDCO's core programs.

I/O data show the flow of commodities to industries from producers and institutional consumers for any given region. The data also show consumption activities by workers, owners of capital, and imports from outside the region. These trade flows built into the model permit estimating the impacts of one sector on other sectors. These impacts consist of the following three types:

- ***Direct*** – the specific impact of the firm or sector(s) in question;
- ***Indirect*** – the impact on suppliers to the firm or sector(s) in question; and
- ***Induced*** – the additional economic impact of the spending of these suppliers and employees in the overall economy.

The IMPLAN model uses detailed sector- and region-specific information to estimate outcomes and to gauge potential impacts. The model incorporates details of more than 420 individual industry sectors that cover the entire regional, state, or national economy. With these sector possibilities, Battelle is able to more precisely model the direct impacts associated with TEDCO's programs and its portfolio of assisted companies using detailed and accurate sector information on the direct impacts of TEDCO's programs. This ability is important, since the supplier characteristics, and hence downstream (indirect) impacts, of each impacted sector are likely to be substantially different.

Total Direct Impacts: TEDCO's Three Core Programs

The direct impacts of the three core TEDCO programs are presented in Table 1, and were defined as follows:

- The direct impacts of the **Technology Commercialization Fund** were the company outcomes reported to TEDCO by the companies participating in the program. The TCF program provides seed funding for companies to commercialize new products based on technology created in Maryland's universities and federal laboratories. Companies are required to report the level of employment, expenditures, revenues, and other impact figures, such as additional funding, resulting from the technology being commercialized.[6] These company operational revenues and expenses represent the estimated direct impact of the TCF program. Although some firms may report their total revenues and employment, not just the revenues and employment associated with the TEDCO-supported technology being commercialized, this is unlikely to significantly impact the estimate since most TCF firms are small, with a median employment of only three workers, and are likely to derive a large share of their revenues from the TCF supported technologies.
- The direct impacts of the **Maryland Innovation Initiative** were the product development expenditures incurred by the 33 projects funded in FY2013. MII program expenditures were used as the only direct impact of the program because the MII program was only initiated in FY2013 and no data on outcomes were yet available.
- The direct impacts of the **Maryland Stem Cell Research Fund** were the research expenditures associated with the program, which were analyzed as occurring in the R&D sector of the Maryland economy.

As presented in Table 1, the direct inputs for the economic impact analysis of the three core TEDCO programs total $335.4 million and 1,225 jobs in FY2013. The overwhelming majority of these impacts are attributable to the operations of the portfolio of 216 companies supported by TEDCO through the TCF program. These companies have an estimated Maryland employment of 1,147 jobs and estimated revenues of $321.3 million. The $10.7 in FY2013 research supported by the Maryland Stem Cell Research Fund is estimated to have directly created 59 jobs, and the $3.4 million in technology development expenditures associated with the Maryland Innovation Initiative are estimated to have directly created 19 jobs.

[6] TEDCO provided a database of 216 companies that received assistance from the Technology Commercialization Fund or its predecessor, the Maryland Technology Transfer and Commercialization Fund, and report to TEDCO on the outcomes of their projects. TEDCO was able to provide recent employment data for 96 of these companies. In order to identify the industry of the portfolio of TCF companies and verify the self-reported employment data, the Battelle-TPP purchased company records from the Hoovers database for the 132 of the 216 TCF companies for which data were available. Between these two databases, employment data were available for 184 companies – 85 percent of the total. Data on type industry, by NAICs code, were available for 132 of these companies, 61 percent of the total. Data for the companies where employment or industry (NAICs code) were unavailable were estimated by Battelle. For the companies where no employment data were available, the median employment figure for the firms where employment data were available was used. Total employment for firms for which no industry data was available were distributed in to industries based on the reported industry for the 61 percent of firms for which industry data was available. Thus, Battelle was able to estimate and employ as the basis for the economic impact analysis data on employment by industry for the entire portfolio of TCF companies. Data for 4 companies were dropped from the economic impact because it was determined that they had no employment in Maryland. Data for 7 companies participating in the Fort Detrick Technology Transfer Initiative (FDTTI) that were not also part of the TCF program were added to this analysis on order to capture the benefits of that smaller program as well.

Table 1: Direct Impacts of TEDCO's Three Core Programs – FY2013

	Revenues or Expenditures[4]	Employment[5]
Three Core TEDCO Programs	$335,432,555	1,225
Technology Commercialization Fund[1]	$321,306,226	1,147
Maryland Innovation Initiative[2]	$3,420,606	19
Maryland Stem Cell Research Fund[3]	$10,705,723	59

(1) TCF Employment - as reported by TEDCO/Estimated by Battelle.

(2) MII Expenditures - treated as technology development expenditures.

(3) MSCRF Research Spending.

(4) TCF Company Revenues were estimated by IMPLAN based on Employment.

(5) MSCRF and MII Direct Employment estimated by IMPLAN based on Expenditures.

Source: TEDCO, FY 2013 Data and Battelle

It is important to note how the direct economic impacts associated with TEDCO differ from those of other state government entities. TEDCO's two core investment programs, TCF and MII, fund the commercialization of technologies, and the MSCRF represents an investment in early-stage, translational stem cell research. These TEDCO programs can be viewed as an investment in a portfolio of companies and research that, unlike many other state government efforts, leverage the initial state funding with additional private capital (in the case of TCF and MII), and with additional federal or private research funding (in the case of MSCRF). Furthermore, the portfolio of companies created, and in many cases the stem cell research projects initiated, remain active in Maryland even after the period of state funding ends, and thus Maryland can capture any benefits associated with the growth of its companies supported and with the technologies commercialized from the funded stem cell research.

Total Estimated Impacts – TEDCO's Three Core Programs in Aggregate

This section presents the results of the economic impact analyses for the three core programs in aggregate, with the discreet program by program results presented below that. For each analysis, Battelle provides the direct effect values driving the model (based upon the operational data provided by TEDCO), the additional estimated, indirect, and induced impacts, and a summation of the total impacts (direct, indirect, and induced). An impact multiplier is also provided for the three model drivers (employment, personal income, and output)—for every one (job or dollar) of direct effect, the multiplier number will equal the total (including the direct effect) number of jobs or dollars created in the regional economy. The following impact data are provided for each analysis: output, labor income (including both wages and benefits), employment, state and local tax revenue, and federal tax revenue.[7]

As presented in Table 2, the economic contribution to the Maryland economy of the three core TEDCO programs totaled $565.9 million in 2013, with a total of 2,835 jobs earning $200.5 million supported, and estimated state and local government revenues of $22.8 million. Total direct research expenditures and portfolio company activities of $335.4 million and employment of 1,225 are augmented with an additional $111.1 million and 719 jobs in *Indirect Impacts* through the local purchases made to support this activity and by $119.3 million and 891 jobs in *Induced Impacts* from the increase in local incomes

[7] The estimation of tax revenue is subject to significant variability due to ever-changing rate structures, the use of available exemptions, and the accounting of potential income, if any, subject to taxation. These figures should be viewed with some measure of caution throughout this analysis.

attributable to TEDCO's three core programs. The $565.9 million in estimated TEDCO-supported impacts results in an output multiplier of 1.69, or $1.69 in economic activity supported for each $1 in research expenditures and portfolio company revenues.

Table 2: Economic Impact of TEDCO's Three Core Programs on Maryland – In Aggregate

	Output ($s)	Labor Income ($s)	Employment	State/Local Tax Revenue ($s)	Federal Tax Revenue ($s)
Direct Effect	$335,432,555	$112,816,364	1,225	$8,677,640	$20,773,223
Indirect Impacts	$111,123,719	$46,324,663	719	$5,727,694	$9,044,938
Induced Impacts	$119,316,619	$41,321,875	891	$8,347,312	$9,036,140
Total Impact	**$565,872,893**	**$200,462,902**	**2,835**	**$22,752,646**	**$38,854,301**
State Impact Multiplier	1.69	1.78	2.31		

Source: Battelle calculations using IMPLAN I/O model of the region.

Total Estimated Economic Impacts – Program-Specific

Economic Impacts of the Technology Commercialization Fund

As presented in Table 3, the portfolio of companies associated with TEDCO's core commercialization program – the Technology Commercialization Fund and its predecessor, the Maryland Technology Transfer and Commercialization Fund – had total direct employment of 1,147 and estimated annual revenues of $321.3 million.[8] As presented in Table 3, the $321.3 million in estimated portfolio company sales generate $539.6 million in economic activity in Maryland, support 2,666 jobs earning $188.7 million, and have an associated $21.7 million in estimated state and local government revenues. Total direct TCF portfolio operating impacts of $321.3 million and employment of 1,147 jobs are augmented with an additional $105.9 million and 679 jobs in *Indirect Impacts* through the local purchases made to support the operations of these companies and by $112.4 million and 840 jobs in *Induced Impacts* from the increase in local incomes attributable to portfolio company operations. The $539.6 million in estimated TCF-supported impacts results in an output multiplier of 1.68, or $1.68 in economic activity supported for each $1 in portfolio company revenues.

Table 3: Economic Impact of the Technology Commercialization Fund on Maryland

	Output ($s)	Labor Income ($s)	Employment	State/Local Tax Revenue ($s)	Federal Tax Revenue ($s)
Direct Effect	$321,306,226	$105,687,995	1,147	$8,309,307	$19,988,155
Indirect Impacts	$105,892,600	$44,124,646	679	$5,487,564	$8,743,513
Induced Impacts	$112,423,210	$38,934,536	840	$7,865,127	$8,656,487
Total Impact	**$539,622,036**	**$188,747,177**	**2,666**	**$21,661,998**	**$37,388,155**
State Impact Multiplier	1.68	1.79	2.32		

Source: Battelle calculations using IMPLAN I/O model of the region.

Economic Impacts of the Maryland Innovation Initiative

[8] Few companies reported revenues, which were estimated based on reported employment by the IMPLAN model. See note 6 for the derivation of the inputs to the analysis.

As presented in Table 4, the $3.4 million in product development activities associated with the Maryland Innovation Initiative generate $6.4 million in economic activity in Maryland, support 41 jobs earning $2.8 million, and have an associated $0.3 million in estimated state and local government revenues. Total direct product development expenditures of $3.4 million and employment of 19 jobs are augmented with an additional $1.3 million and 10 jobs in *Indirect Impacts* through the local purchases made to support this product development activity and by $1.7 million and 13 jobs in *Induced Impacts* from the increase in local incomes attributable to these development-related expenditures. The $6.4 million in MII-supported impacts results in an output multiplier of 1.86, or $1.86 in economic activity supported for each $1 in product development expenditures.

Table 4: Economic Impact of the Maryland Innovation Initiative on Maryland

	Output ($s)	Labor Income ($s)	Employment	State/Local Tax Revenue ($s)	Federal Tax Revenue ($s)
Direct Effect	$3,420,606	$1,726,092	19	$89,190	$294,248
Indirect Impacts	$1,266,684	$532,721	10	$58,146	$105,929
Induced Impacts	$1,669,198	$578,080	13	$116,758	$128,522
Total Impact	**$6,356,488**	**$2,836,893**	**41**	**$264,094**	**$528,699**
State Impact Multiplier	1.86	1.64	2.18		

Source: Battelle calculations using IMPLAN I/O model of the region.

Economic Impacts of the Maryland Stem Cell Research Fund

As presented in Table 5, the R&D activities associated with the Maryland Stem Cell Research Fund generate $19.9 million in economic activity in Maryland, support 128 jobs earning $8.9 million, and have an associated $0.8 million in estimated state and local government revenues. Total direct research expenditures of $10.7 million and employment of 59 research jobs are augmented with an additional $4.0 million and 30 jobs in *Indirect Impacts* through the local purchases made to support this research activity and by $5.2 million and 39 jobs in *Induced Impacts* from the increase in local incomes attributable to these research expenditures. The $19.9 million in estimated MSCRF-supported impacts results in an output multiplier of 1.86, or $1.86 in economic activity supported for each $1 in research expenditures.

Table 5: Economic Impact of the Maryland Stem Cell Research Fund on Maryland

	Output ($s)	Labor Income ($s)	Employment	State/Local Tax Revenue ($s)	Federal Tax Revenue ($s)
Direct Effect	$10,705,723	$5,402,277	59	$279,143	490,820
Indirect Impacts	$3,964,435	$1,667,296	30	$181,984	195,496
Induced Impacts	$5,224,211	$1,809,259	39	$365,427	251,131
Total Impact	**$19,894,369**	**$8,878,832**	**128**	**$826,554**	**$937,447**
State Impact Multiplier	1.86	1.64	2.18		

Source: Battelle calculations using IMPLAN I/O model of the region.

Projected 2018 Impacts of TEDCO's Three Core Programs

TEDCO's operations generate an expanding portfolio of research and companies assisted. The impacts associated with TEDCO's operations will increase as the portfolio of TEDCO-assisted companies grows, through both the growth of the existing portfolio companies and the addition of new companies assisted by TEDCO's programs. Battelle projected the five-year growth in the economic impacts associated with TEDCO's three core programs and their resultant research and commercialization activities based on the following assumptions:

- The existing portfolio of companies will experience four percent annual growth in employment, based on the average of the growth of the portfolio companies for which employment was available over the past five years and on longitudinal data from the specialized, proprietary National Establishment Time-Series (NETS) database that was specifically created to study the dynamics of businesses across the United States;[9]
- A total of 15 new companies will be assisted by TCF each year, a number smaller than the 17-22 companies assisted in past years, in order to provide a conservative estimate of portfolio growth;
- A total of 15 new companies will be formed based on the MII program;[10] and
- Each of the new companies formed will have three employees, the median employment level of the entire portfolio analyzed.

As presented in Table 6, the economic contribution to the Maryland economy of TEDCO's three core programs is projected to grow to $910.3 million in 2018, supporting a total of 4,527 jobs earning $320.3 million, and estimated state and local government revenues of $36.6 million.

Table 6: Projected 2018 Economic Impact of TEDCO's Three Core Programs on Maryland

	Output ($s)	Labor Income ($s)	Employment	State/Local Tax Revenue ($s)	Federal Tax Revenue ($s)
Direct Effect	$540,860,995	$179,787,469	1,951	$13,989,501	$33,471,275
Indirect Impacts	$178,687,222	$74,472,960	1,151	$9,236,463	$14,622,292
Induced Impacts	$190,722,515	$66,051,248	1,425	$13,342,885	$14,534,334
Total Impact	**$910,270,732**	**$320,311,677**	**4,527**	**$36,568,849**	**$62,627,901**
State Impact Multiplier	1.68	1.78	2.32		

Source: Battelle calculations using IMPLAN I/O model of the region.

The projected five-year growth in the economic impacts associated with TEDCO's three core programs from $565.9 million in economic activity and 2,835 jobs currently to $910.3 million and 4,527 jobs in

[9] NETS was developed by Walls & Associates in partnership with Dun and Bradstreet (D&B). NETS converts D&B archival establishment data into a time series database of establishments that contains data on employment by establishment over time. NETS provides the ability to follow an establishment over time as it was formed, grew, contracted or changed corporate form. Annual rates of growth for the existing portfolio of companies were calculated for each of the past five years based on the year of company formation. Given that that the past five year period used includes the recent "Great Recession," a period of considerable economic dislocation, these estimates can be viewed as conservative.

[10] Because the MII program is new, the number of projects that will lead to the successful formation of a company is not yet known. The number used in the projections analysis was based on the current level of funding of over 30 projects combined with the company formation rate of its predecessor UTDF and TechStart programs, for which 44 percent of projects resulted in a start-up company.

2018 represents a 61 percent increase in TEDCO-supported economic activity and a 60 percent increase in TEDCO supported employment. This analysis is based on current levels of state support and funding.

Summary and Conclusion – Economic Impact Analysis

TEDCO makes a significant economic contribution to the Maryland economy. TEDCO's economic impact was not analyzed as a simple source of expenditures because its investment in technology transfer, commercialization, and product development activity has created, and continues to grow, a portfolio of companies that are key drivers of Maryland's high technology business cluster and technology-commercialization community. This activity capitalizes on Maryland's existing research assets to create an ever-growing collection of on-going economic contributors, its portfolio of companies, many of which might not exist except for the early-stage funding that TEDCO provided when those companies were at their most critical stage of development. Similarly, the MSCRF is an investment that is keeping Maryland competitive in the area of stem cell science, which will lead to future economic activities as this promising science matures and leads to a variety of new products. This investment ensures that Maryland will be well-positioned to take advantage of the economic opportunities that such new products will generate. Overall in 2013, the portfolio of TCF commercialization-based companies, the new university commercialization program (MII), and the core research program (MSCRF) directly supported $335.4 million in economic activity and 1,225 jobs in Maryland. When multiplier effects are included, their economic contribution totaled $565.9 million, with a total of 2,835 jobs earning $200.5 million supported, and estimated state and local government revenues of $22.8 million.

Based on that estimated 2013 combined state and local government revenues of $22.8 million, Battelle estimates the total Maryland state government portion alone to be $12.6 million[11] in 2013. These estimated state tax revenues represent 66 percent of TEDCO's FY2013 state appropriation of $19.0 million. Approximately $12.1 million of those state tax revenues are attributable to TCF and MII, the core commercialization and technology support programs. As of fiscal 2013, the State of Maryland has invested a total of $154 million in TEDCO. Just over one-third of that state funding, $52.4 million, has supported TEDCO's TCF and MII programs, with the remaining two-thirds going to the Maryland Stem Cell Research Fund.

Battelle calculated an estimated 2013 return on investment of the State of Maryland's investment in TEDCO's core commercialization and technology support programs, TCF and MII. This return on investment analysis excludes the MSCRF because that is an investment in early-stage, translational research and thus cannot be expected to generate immediate economic and fiscal returns to the state. Economic and fiscal returns from MSCRF can be expected in the future as the stem cell sector grows and matures and research results are commercialized. **Focusing narrowly on the estimated state tax revenues associated with TCF and MII, the 2013 return on its investment totals 23 percent.**[12] Based on current levels of investment in TEDCO and the projected growth of the portfolio of companies assisted by TCF and MII, the return on investment is projected to increase to 27 percent in 2018.

[11] The IMPLAN model used estimates of total ***combined*** state and local revenues from a variety of major revenue sources, including income, property and sales taxes and other revenues. Battelle distributed these IMPLAN estimated combined state and local revenues into their separate state and local revenue components estimates based on the distribution of state versus local revenues derived by each major revenue source from the U.S. Bureau of the Census *State and Local Government Finances Summary: 2011* report.

[12] Calculated by dividing $12.1 million in estimated state government revenues from TEDCO's CTF and MII programs by total state investment to date in those programs of $52.4 million.

FUNCTIONAL IMPACTS OF TEDCO'S OVERALL OPERATIONS

The Maryland Technology Development Corporation was created by the Maryland State Legislature in 1998 to facilitate the transfer and commercialization of technology from Maryland's research universities and federal labs into the marketplace and to assist in the creation and growth of technology-based businesses in all regions of the state.

TEDCO's Mission is ***to facilitate the creation and growth of businesses throughout all regions of the state by supporting entrepreneurship and innovative technologies.***

TEDCO's Vision is that ***Maryland will be internationally recognized as a premier location for innovation, entrepreneurship and company formation with:***

- ***Multiple innovation clusters;***
- ***A large, established entrepreneurial community; and***
- ***A thriving venture capital community.***

TEDCO was created to address a specific and critical gap in Maryland's economic development strategy. As home to major public and private universities, such as Johns Hopkins and the University System of Maryland, and federal research facilities, ranging from the Beltsville Agricultural Research Center, the largest agricultural research center in the world, to the National Institutes of Health, the largest biomedical research facility in the world, to major federal defense and space research facilities, Maryland is at the forefront on research and development in a number of critical fields. Maryland's national prominence in research and development is evident in the following data from the Maryland Department of Business and Economic Development:

- Johns Hopkins University ranks first among U.S. colleges and universities in total National Institutes of Health awards, including grants and contracts for research, development, training and fellowships ($645 million).
- Maryland ranks first in National Institutes of Health R&D contract awards ($656 million).
- Johns Hopkins University ranks first among academic institutions in the nation in research and development expenditures, totaling $2.15 billion in FY2011. The university also ranks first in federally funded research ($1.88 billion).
- Maryland ranks second in federal obligations for research and development ($15.9 billion). On a per capita basis, Maryland ranks first among the states in federal R&D obligations.
- Maryland ranks second in research and development intensity, which is the ratio of R&D expenditures to gross domestic product (GDP) by state. Maryland ranks fourth in total R&D performance, first in federal intramural R&D, and fourth in R&D performed at universities and colleges.[13]

Maryland is a recognized international leader in research and development, but has lagged in the commercialization of this research. This commercialization gap has been explicitly recognized in both national studies of technology development and the State of Maryland's economic development strategy, as the following points illustrate:

[13] http://choosemaryland.org/factsstats/Pages/Rankings.aspx.

- The Milken Institute's 2012 State Technology and Science Index ranked Maryland 2nd nationally in terms of its science and technology capabilities and performance, but reports that, "***Maryland's weakness is in the risk capital and entrepreneurial infrastructure category, an area in which it has consistently underperformed***."[14]
- The commercialization gap is explicitly recognized in the Charting Maryland's Economic Path strategic plan which reports that "***Maryland's unparalleled research riches are not reflected in its commercialization track record***" and specifically recommends efforts to ***"Reinvigorate and bring critical mass to Maryland's commercialization resources."***[15]

Maryland is successful in generating research discoveries, but has been less successful in terms of the transformation of these research discoveries and new technologies into companies and jobs. Technology transfer and commercialization are the vital links in translating research and innovations into jobs and economic activity. According to the State Science and Technology Institute (SSTI), "Much of the success of Silicon Valley can be attributed to the success in transferring knowledge and technology from universities to the private sector and among companies. Spillovers of knowledge can be accomplished by identifying and removing barriers to the commercialization of university-developed technology, encouraging access to federal laboratories, and providing seed funding to industry associations and technology councils that promote communication among companies"[16] TEDCO was formed to address the commercialization gap in Maryland, and its core programs specifically target expanding the commercialization of the state's strong base of research and development activity.

This section of the report will first describe the Battelle model for state-level technology-based economic development. It will then describe the state-level technology-based economic development system in Maryland, including key research and venture capital performance metrics. The report will then go on to describe TEDCO's role in Maryland's economic development strategy and in Maryland's technology-based economic development system and describe both the need for and utilization of TEDCO's key programs.

Battelle Technology-Based Economic Development Model

Economic development is not easy to achieve in general, and technology-based economic development is an even greater challenge. The successful development of technology-based business sectors depends on a chain of factors that is particularly complex and challenging to develop and manage. The states and regions in the U.S. which have achieved success in technology-based economic development (places such as California and Massachusetts) have mature technology development chains in place. These technology-based economic development chains may form naturally over time (as occurred in Silicon Valley and Boston), or they may result from the dedicated activities of states, regions and key stakeholders to connect and build links in the chain to assure such development happens (as occurred in the Research Triangle area). Figure 1 illustrates a basic technology-based economic development chain and the specific links that need to be in place to create and grow a technology cluster.

As presented in Figure 1, the Technology-Based Economic Development Chain begins with *Basic Science*. New discoveries, technologies and innovations are refined though *Applied Development*, tested through *Piloting and Demonstration* and finally deployed into the business community through

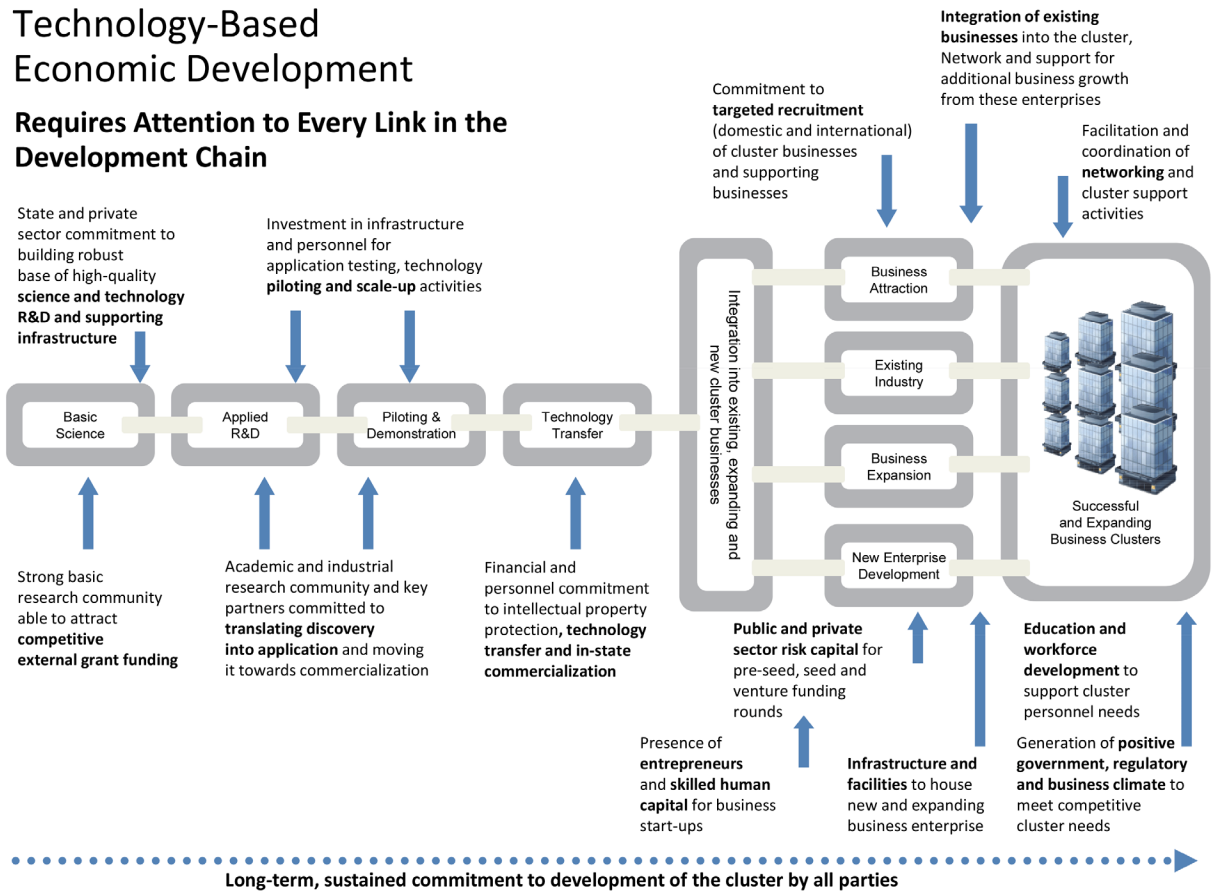
[14] http://www.milkeninstitute.org/publications/publications.taf?function=detail&ID=38801405&cat=resrep.

[15] http://www.governor.maryland.gov/documents/MEDCreport.pdf.

[16] "*What is TECHNOLOGY-BASED ECONOMIC DEVELOPMENT*" at http://sstievents.org/TECHNOLOGY-BASED ECONOMIC DEVELOPMENT.

Technology Transfer. Technological innovations can be deployed both through existing businesses and through *New Enterprise Development* through start-up companies. Start-up company formation further requires the presence of entrepreneurs, business capital, and often infrastructure and facilities to house new companies. These are the key links in the technology-based economic development chain and are the core focus of technology-based economic development efforts across the country and of TEDCO's operations in Maryland.

Figure 1: Links in the Technology-Based Economic Development Chain



Successful technology-based economic development efforts require more than simple technology transfer efforts – they require technology commercialization. Technology transfer is the passive management of a research organization's intellectual property, which is secured to protect discoveries resulting from basic research activity. Technology transfer involves disclosure of discoveries, the determination of the need for patent protection, and the licensing of the intellectual property (to either a third-party organization or as part of the creation of a new business) to pursue the development of a product or process based on the discovery.

Technology commercialization, on the other hand, involves moving beyond legal protection and licensing. It requires developing the technology into a product or service to meet the need(s) of customers in the marketplace. Technology commercialization is often called applied research. Unlike the stages of technology transfer (shown in Table 7) where the research arises from the search for improved knowledge and understanding, technology commercialization is the deployment of new technologies and innovations into the marketplace to meet the needs of customers, eventually resulting in a profit from its sales and use.

Table 7: Technology Transfer vs. Technology Commercialization – Stages

	Technology Transfer		*Technology Commercialization*		
Technology Development Stage	Discovery	Translational Research	Technology Development	Product Development	Production/Marketing
Outcome	• Invention Disclosure • Publication	• Proof of Concept • Patent/Trade Secret • License	• Engineering Optimization • Product Prototype • Pre-seed business	• Initial Product • Start-up business or new program (for established companies)	• Mass Production • Established company

Source: Adapted from NIST, "ATP and Venture Capital Funding Criteria Differ," http://www.atp.nist.gov/factsheets/1-c-9.htm

Technology commercialization links industry (existing businesses and new enterprises/entrepreneurs) with the research being developed by universities and federal laboratories. Technology commercialization is primarily concerned with building and growing new products and processes in existing or new firms, and involves a number of key steps, including:

- Assessing the technology and its potential markets against current products in the marketplace;
- Developing the product itself, and optimizing its engineering and design to meet the price points of the marketplace;
- Putting the business and management team in place; and
- Securing the sources of equity and working capital that will carry the product and/or firm through various stages of maturity until it becomes an established company/product in larger domestic and global markets.

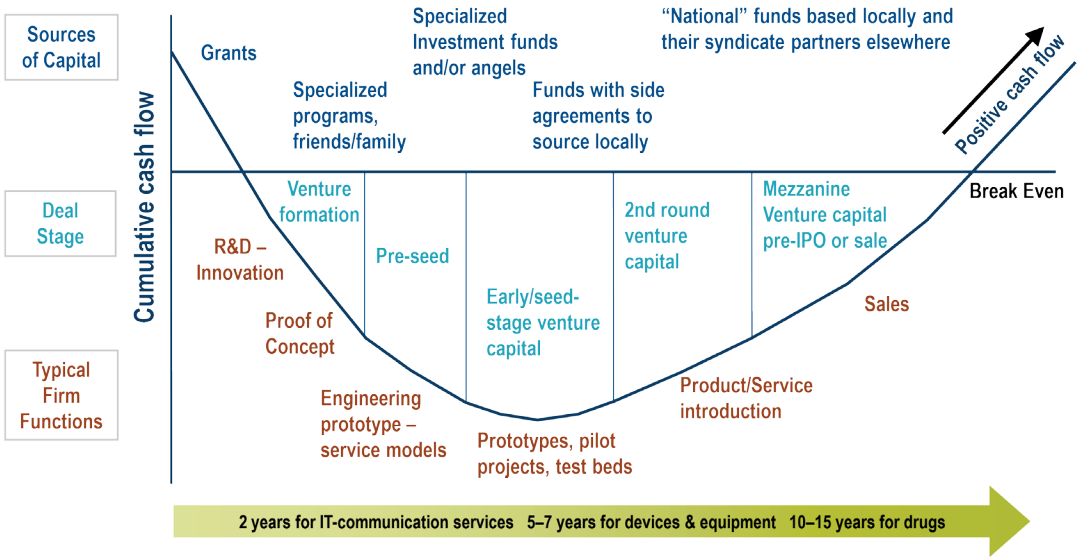
Technology commercialization brings together the technology created through research and development, entrepreneurial management talent to manage and steer the firm or product into and through the marketplace, and risk capital to develop and engineer the product for manufacture and distribution. The three key elements of technology commercialization are:

1. The technology itself;
2. Entrepreneurial or management talent; and
3. Risk capital.

Moving From Research Discovery to the "Valley of Death"

The focus of technology transfer and technology commercialization is turning basic research into firms and products with sales in the marketplace. As presented above, technology commercialization requires a technological innovation as well as entrepreneurial/managerial talent and the risk capital to finance the creation of the new product or service. The financial aspects of technology commercialization have been called the "Valley of Death," with financial cash flow elements and sources of capital varying by stage in the commercialization process. Research has demonstrated that gaps within the "Valley of Death" impede the commercialization process.

Figure 2: Risk Capital and Technology Commercialization – The "Valley of Death"



This "Valley of Death" illustration demonstrates the need for a continuum of support, services, and assistance from the private and public sectors throughout the commercialization process as a technology enterprise is conceived, developed, formed, grown, and brought to maturity. Tools needed include due diligence, proof of concept, engineering optimization in developing the technology and identifying the product, managerial and entrepreneurial support, and access to risk capital. These are the foci of TEDCO.

The Technology-Based Economic Development Ecosystem in Maryland

Maryland has been successful in technology-based economic development. Nearly every national report on high technology sectors places Maryland among the top states in terms of the strength and dynamism of its technology sector, with Maryland ranked as follows by a selection of the major national technology industry reports:

- The Milken State Science and Technology Index ranks Maryland second nationally in its overall science and technology index;
- The Information Technology and Innovation Foundation (ITIF) ranks Maryland fifth overall in terms of its State New Economy Index (down from 3rd in 2010);[17]
- According to the Pharmaceutical Research and Manufacturers of America Maryland has the 9th largest biopharmaceutical sector in the U.S.;[18] and
- According to the Biotechnology Industry Organization, Maryland is ranked 15th nationally in terms of the overall size of its biosciences industry with Maryland having a high degree of specialization in life sciences research and drugs and pharmaceuticals.[19]

However, many of these national reports recognize that Maryland's high technology business base is strongly dependent on its proximity to the federal government and large federal contracting base.

[17] http://www2.itif.org/2012-state-new-economy-index.pdf.

[18] Individual state data from http://www.phrma.org/economic-impact analyzed by Battelle.

[19] Individual state data from http://www.bio.org/sites/default/files/v3battelle-bio_2012_industry_development.pdf. analyzed by Battelle

According to the ITIF report, Maryland's ranking is "primarily due to high concentrations of knowledge workers, many employed with the federal government or related contractors in the suburbs of Washington, D.C." While this has historically been good for the Maryland economy, strong reliance on federal spending bodes poorly for the future in an era of federal downsizing and sequestration. As described below, Maryland lags in the commercialization of technologies based on its large base of university and federal research. The Milken State Science and Technology Report finds that, despite Maryland's strength in research and development and high concentration of high technology workers, the state's weakest areas are ***access to risk capital*** and its ***entrepreneurial infrastructure***.

Maryland is a successful high technology state. Its success is derived from its strong base of university and federal research combined with its strong base of technology-focused federal and defense contractors. Despite these significant strengths, Maryland has been less successful in developing a sustained track record of entrepreneurial success based on its immense research assets. Maryland's gaps in technology commercialization and entrepreneurial success are best illustrated in the measures of university commercialization and venture capital investment described below.

University Research and Technology Transfer

As presented in Table 8, Maryland's strong base of research activity is evident in its fourth place ranking among benchmark states in total university research, despite having a far smaller economy than many of the benchmark states. Indeed, according to the National Science Foundation, when university research activity is normalized by the size of the state's economy, Maryland is ranked first nationally in academic science and engineering R&D expenditures as a share of gross domestic product, with $10.60 per $1,000 in GDP, compared to $6.83 in Massachusetts (2nd nationally), $5.31 in North Carolina (5th), $4.98 in Pennsylvania (11th) $4.10 in Ohio (21st), $4.01 in California (22nd) and $3.47 in Texas (31st). In fact, academic research as a share of gross domestic product in Maryland is almost three times the national average.[20] In terms of gross measures of technology generation and commercialization, Maryland's position relative to the benchmark states falls to fifth in terms of the number of Invention Disclosures and Patents Issued, and to eighth among the nine benchmark states in the number of university-based start-ups formed.

Table 8: University Technology Commercialization in Maryland Compared to Benchmark States

State	Total Research Expenditures (Mil. $s)	Invention Disclosures	U.S. patents issued	Start-ups Formed
Maryland	$3,594	944	162	16
California	$7,341	2,727	794	72
Colorado	$1,247	373	52	18
Massachusetts	$3,609	1,341	366	38
North Carolina	$2,321	794	140	27
Ohio	$1,826	807	108	22
Pennsylvania	$3,164	1,250	248	48
Texas	$3,831	1,233	288	34
Virginia	$980	466	76	15
United States	**$55,931**	**20,964**	**4,542**	**647**

Source: Battelle calculations using 2012 AUTM Data.

[20] http://www.nsf.gov/statistics/seind12/c8/interactive/table.cfm?table=46.

Although Maryland's competitive position compared to benchmark states appears relatively strong in terms of gross measures of university research, technology generation and commercialization, when university technology generation and commercialization outcomes are normalized by the level of research activity occurring in each state, a commercialization and entrepreneurial activity gap between Maryland and the benchmark states becomes evident. As presented in Table 9, Maryland's levels of university technology generation and commercialization per $10 million in university research expenditures lag benchmark states and the national average in each of the core measures analyzed. In 2012, Maryland universities generated:

- 2.63 Invention Disclosures per $10 million in research, compared to 3.75 per $10 million nationally;
- 2.86 patent applications and 0.45 patents awarded per $10 million in university research, compared to 3.50 and 0.81 respectively nationally;
- 0.02 licenses per $10 million and $51,467 million in license income per $10 million in research, compared to 0.08 and $344,780 nationally; and
- 0.04 university technology-based start-ups per $10 million, compared to 0.12 nationally.

On most of these measures, Maryland not only lags the national average but falls far below all of the benchmark states.

Table 9: University Technology Commercialization in Maryland Compared to Benchmark States, Normalized per $10 Million in Research Expenditures

State	Metrics per $10M in Research Expenditures					
	Invention Disclosures	Start-ups	New Patent Applications	U.S. Patents Issued	Licenses & Options Executed	License Income
Maryland	2.63	0.04	2.86	0.45	0.02	$51,467
California	3.71	0.10	4.21	1.08	0.08	$291,937
Colorado	2.99	0.14	2.54	0.42	0.10	$272,717
Massachusetts	3.72	0.11	3.91	1.01	0.10	$580,368
North Carolina	3.42	0.12	2.95	0.60	0.24	$146,223
Ohio	4.42	0.12	3.41	0.59	0.08	$97,471
Pennsylvania	3.95	0.15	3.13	0.78	0.08	$155,654
Texas	3.22	0.09	2.45	0.75	0.06	$248,675
Virginia	4.75	0.15	5.59	0.78	0.09	$99,206
United States	3.75	0.12	3.50	0.81	0.08	$344,780

Source: Battelle calculations using 2012 AUTM Data.

The lower level of commercialization activity from Maryland's colleges and universities is also evident in the number of university-based, start-up companies. Over the past five years, a total of 92 university technology-transfer-based start-ups were formed in Maryland, the third lowest level among the benchmark states.

University Initiated Start-ups 2008–12	
Maryland	92
California	406
Colorado	76
Massachusetts	195
North Carolina	114
Ohio	109
Pennsylvania	153
Texas	165
Virginia	65

Source: AUTM

Venture Capital Investment

Maryland also lags benchmark states in terms of venture capital investment, both when examined in total and when the amount of venture capital is normalized by the level of R&D activity in each state. As presented in Table 10, Maryland had 723 venture capital deals and $4.7 billion of venture capital investment over the 2007–13 period, ranked seventh out of the nine benchmark states. In terms of supporting technology commercialization, seed and early-stage venture capital investment are the most important types of investments to support the development of technology-based start-up companies. Over this period, Maryland had 232 early-stage venture capital deals and associated investment of $899 million, ranked sixth out of the benchmark states. As presented in Table 11, Maryland lags the nation and most of the benchmark states in terms of both total venture capital deals and investment per $10 million in research,[21] with only about half the national number of deals per $10 million, and about one-third the level of investment per $10 million. Similarly, in terms of seed and early-stage venture capital investment per $10 million in research, Maryland lags the nation and most benchmark states, with less than half the national levels.

Table 10: Total Venture Capital Investment, 2007–13

State	Total Venture Capital Deals		Seed and Early-Stage Venture Capital Deals	
	Deals	Millions of $s	Deals	Millions of $s
Maryland	723	$4,731	232	$899
California	13,224	$115,968	5,141	$28,824
Colorado	947	$7,410	322	$1,540
Massachusetts	3,599	$24,645	1,339	$8,643
North Carolina	494	$4,108	123	$707
Ohio	573	$9,203	261	$628
Pennsylvania	1,543	$5,552	621	$1,202
Texas	1,517	$20,415	402	$1,642
Virginia	693	$4,499	202	$652
United States	34,265	$294,634	12,367	$58,331

Source: Thomson Reuters ThomsonOne venture capital database

[21] Data are for 2010 because this is the most recent year for which total state R&D figures were available.

Table 11: Venture Capital Investment Normalized by R&D, 2010

State	Total Venture Capital Deals		Seed and Early-Stage Venture Capital Deals	
	Deals per $10 Mil. in R&D	$s per $10 Mil. in R&D	Deals per $10 Mil. in R&D	$s per $10 Mil. in R&D
Maryland	0.06	$0.30	0.02	$0.08
California	0.23	$1.76	0.08	$0.43
Colorado	0.20	$0.83	0.07	$0.22
Massachusetts	0.25	$1.64	0.10	$0.62
North Carolina	0.09	$5.08	0.03	$0.15
Ohio	0.07	$0.22	0.04	$0.07
Pennsylvania	0.16	$0.50	0.06	$0.11
Texas	0.12	$0.71	0.03	$0.16
Virginia	0.09	$1.05	0.02	$0.06
United States	0.12	$1.11	0.04	$0.19

Source: Battelle calculations using NSF State R&D figures and Thomson Reuters ThomsonOne venture capital database

TEDCO's Role in Maryland's Overall Economic Development Strategy

Maryland is well-positioned for technology business and commercialization-led economic growth. Not only does the state have a considerable base of internationally competitive academic and federal research and development activity, it also possesses a strong base of technology businesses. According to the Milken Institute, "Of note is an increase in the percentage of people employed in high-tech industries (while the average for all states in this indicator declined). Maryland is well-positioned for the future with a first-place ranking in the percent of high-tech establishment births (14.5 percent of all new establishments)." Linking the two by expanding technology commercialization is specifically targeted by the Maryland Economic Development Commission's *Charting Maryland's Economic Path: Discovery, Diversity & Opportunity: A Five Year Strategic Plan*. This plan identifies ***turning new knowledge into economic success: commercialization*** as one of the key foundations of Maryland's economic development strategy, and reports the following:

> A concentration of technology firms and research and development facilities is not enough to make an area vibrant. Economic benefit accrues to the locations where commercialization of the innovations generated by new knowledge takes place. Strong collaborative relationships—"connecting the dots"—among innovators and technology generators, technology-users, and services providers are required in order to connect younger firms and entrepreneurs to services, buyers, suppliers, partners, and innovations. These connections help them cut costs, expand markets, improve customer service, become more competitive and support the growth of local suppliers. The key metric for commercialization is sales, which leads to job creation.

TEDCO and its core programs are specifically identified as important in the Maryland Economic Development Commission's economic development strategy which recommends efforts to:

- Reinvigorate and bring critical mass to Maryland's commercialization resources;
- Invest in existing commercialization vehicles, knit them together, and align them with state and federal initiatives;
- Bring needed capital to commercialization efforts;

- Further develop an innovation cluster by integrating, cross-fertilizing and accelerating commercialization activity in Maryland's incubators, research parks and shared research/development/testing facilities; and
- Leverage the federal laboratory presence in the state.

Research, technology commercialization and entrepreneurship are explicitly part of several other key foundations of the Commission's economic development strategy. Specifically, TEDCO is central to the following key foundations of the state strategy, which state the following:

- ***Sources of discovery and innovation:*** Innovation and collaboration are critical success factors in today's global economy. Research and statistical analyses of technology industry locations and growth have concluded that a strong base of research and development (R&D) is the essential foundation for building an innovation-based economy. Usually, this intellectual infrastructure takes the form of a research university, but it may also include a federal laboratory or large research-intensive companies that are leaders in their industry ("pillar" companies). Fast-growing companies ("gazelles") thrive in places of all sizes that have a cross disciplinary R&D base. Building on the state's foundations, this strategy aims to pull together the elements to make Maryland a regional innovation cluster.
- ***Entrepreneurship: the fuel driving a dynamic economy:*** Fast growing companies will generate much of the new private job growth. Maryland lags in innovation-based start-ups and employment growth from young companies. Steady federal customer availability has tended to act as a drag on entrepreneurial culture and dampen the community's tolerance for risk-taking and failure.
- ***Financial Capital: money to grow:*** In addition to ideas, workers, and strong management, innovation-driven companies—like all others—need money. In the case of innovative companies, the capital being sought must come from individuals and institutions that are well accustomed to dealing with technology, market, management, and production risks. These financiers often become closely involved in the operations of the company, adding expertise and relationships along with financing. When the product development cycle is a long one, substantial equity capital as well as debt must be obtained. Public finance mechanisms provided by the state are not intended to supplant private capital, yet can play a critical role in reducing risk for the lender or investor, and lowering the cost of capital to the company.

The economic development strategy prepared by the Maryland Economic Development Commission identifies expanding technology commercialization as key to Maryland's economic development efforts and future. TEDCO's mission and efforts are directly related to achieving economic development success and are directly related to four of the seven key foundations of Commission's economic development strategy, and TEDCO's efforts are identified seven times in the strategy. ***It is clear from this that TEDCO's mission and programs are central to Maryland's economic development efforts***.

TEDCO is also identified by the Milken Institute in its analysis of Maryland in the State Technology and Science Index. According to the Milken Institute:

> Maryland's weakness is in the risk capital and entrepreneurial infrastructure category, an area in which it has consistently underperformed. However, the state's leadership is working on programs to attract funding and streamline the commercialization of university research. InvestMaryland has raised close to $84 million by auctioning

premium tax credits to insurance companies. This money is used to fund start-ups and help fill the existing venture capital gap. Similarly, Innovate Maryland seeks to move discoveries from academia into the marketplace more quickly. Support is provided through TEDCO, Maryland's state run technology transfer organization, and the goal is to commercialize 40 inventions a year.

The other leading national analyses of state science and technology efforts recognize the importance of creating state-level technology-based economic development organizations like TEDCO. According to the ITIF's 2012 State New Economy Index, "Another effective technology policy is to create a statewide commercialization and entrepreneurship organization. Indeed, states should have at least one organization committed to maximizing both commercialization and entrepreneurship as part of its mission." The National Academy of Sciences in its recent report, *Best Practices in State and Regional Innovation Initiatives: Competing in the 21st Century*, says "*Innovation intermediary organizations often make significant contributions to innovation-based economic development*. Often possessing a deep knowledge of local research and workforce competencies, innovation-based economic development organizations can align local institutions, assets, skills, and resources to advance the innovation potential of states and regions."

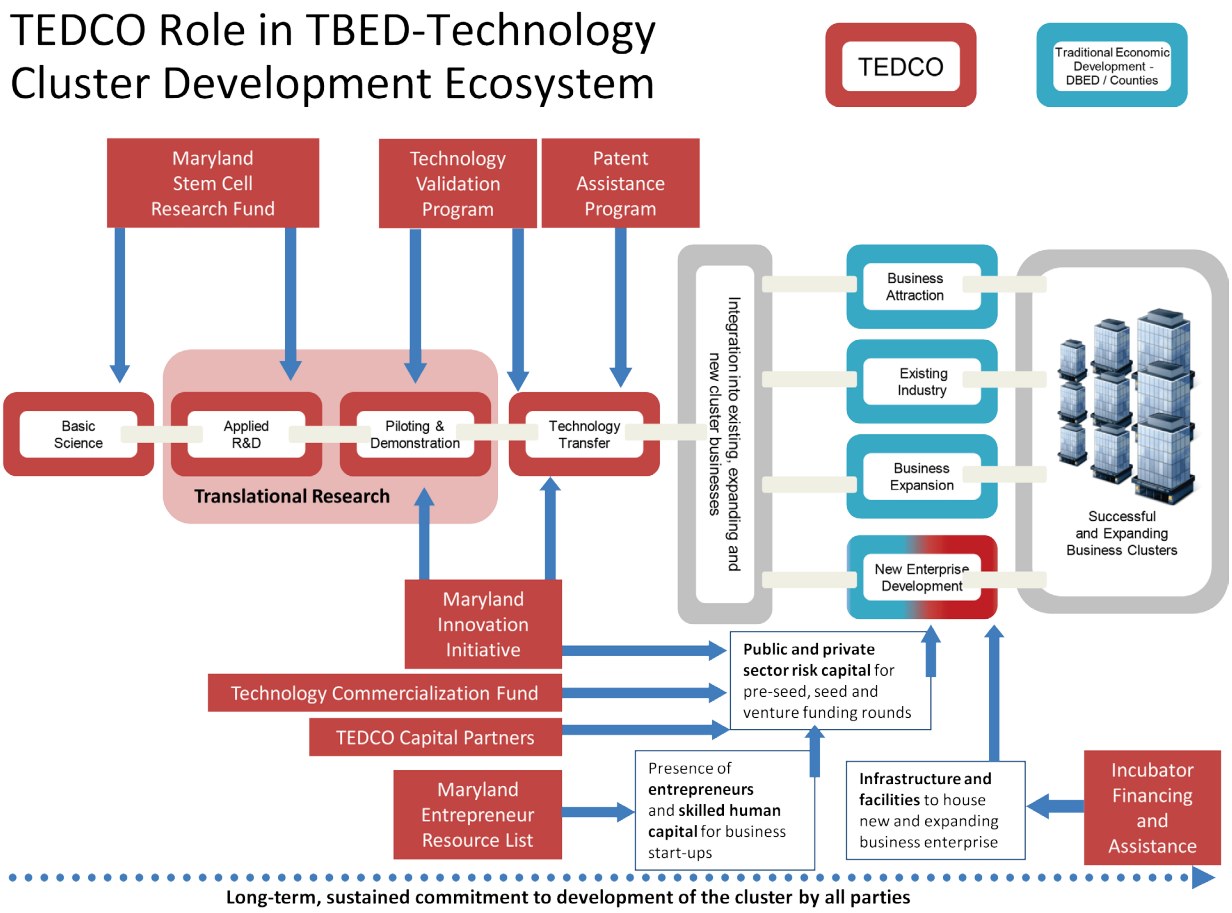
Thus, not only is TEDCO a core component of the State of Maryland's economic development strategy, it is consistent with national best practices for technology-based economic development.

TEDCO's Role in The Maryland Technology-Based Economic Development Ecosystem

Based on the analysis conducted, TEDCO is clearly an integral component of Maryland economic development strategy which specifically targets expanded technology commercialization through enhanced technology transfer, support for entrepreneurial development, and expanded access to financial resources such as venture capital. Indeed, these are the key areas targeted by TEDCO's core programs. TEDCO's role in the Battelle Technology-Based Economic Development Chain is presented in Figure 3, with TEDCO's core programs and where they impact the Maryland Technology-Based Economic Development Chain identified in red. Traditional economic development organizations, most importantly the Maryland Department of Business and Economic Development, and regional and county economic development offices, are identified in turquoise.

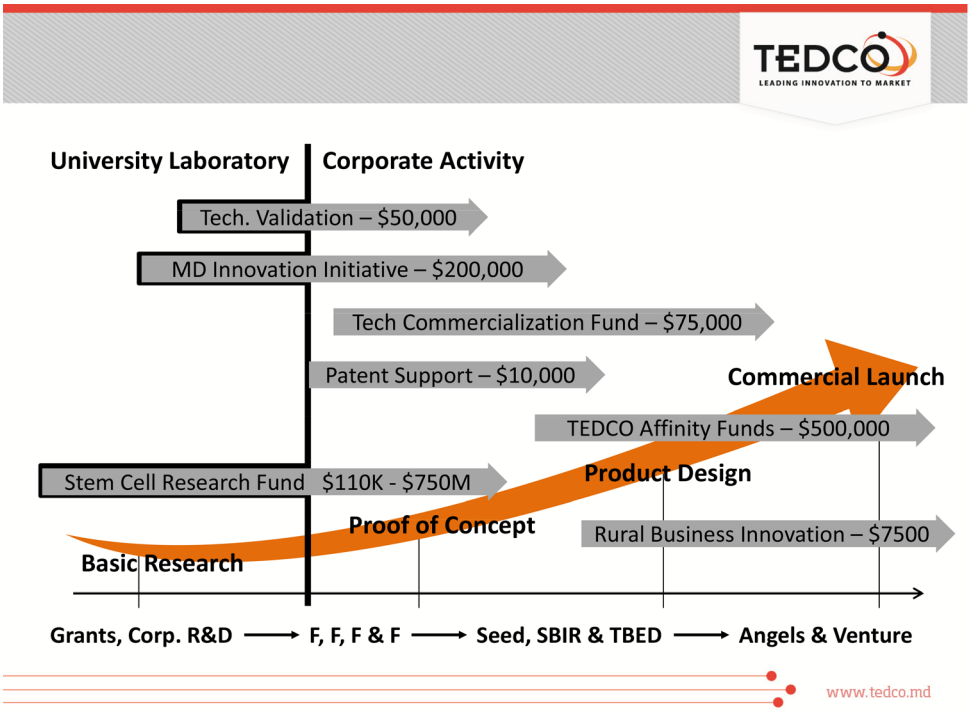
It is evident from Figure 3 that TEDCO's core programs play a central role in all aspects of the Maryland Technology-Based Economic Development Chain related to technology generation, transfer and commercialization from *Basic Science* through *Applied Development* and *Piloting and Demonstration* and finally to *Technology Transfer*. TEDCO's programs also contribute to *New Enterprise Development* though its support for entrepreneurship, the provision of risk capital, and support for business incubation.

Figure 3: TEDCO's Role in Maryland's Technology-Based Economic Development Chain



TEDCO also plays an important role in addressing the "Valley of Death" previously described. Technology commercialization is the process of turning basic research into firms and products with sales in the marketplace and requires a technological innovation, entrepreneurial/managerial talent, and the risk capital to finance the creation of the new product or service. The financial requirements of technology commercialization vary by stage in the commercialization process, and gaps in financing availability—the "Valley of Death"—significantly negatively impact the chance of success of the commercialization effort. As presented in Figure 4, TEDCO offers a number of different programs by stage in the commercialization process to meet the needs of both companies and entrepreneurs. The Maryland Stem Cell Research Program funds basic research in this important area of technology development, and the Maryland Innovation Initiative and Technology Commercialization Fund supply capital to the technology transfer, proof of concept, and product design phases. The TEDCO Technology Validation and Patent Support programs also provide a needed source of capital during these phases. Finally, TEDCO's Affinity Funds and Rural Business Innovation Initiative provide both access to capital and technical support.

Figure 4: TEDCO's Role in Risk Capital and Technology Commercialization – Addressing the "Valley of Death"



Descriptions and Outcome Measures for TEDCO's Key Programs

TEDCO provides a full menu of programs designed to support and facilitate the generation, transfer, and commercialization of technology in Maryland. TEDCO was created to assist Maryland in enhancing and capturing the economic benefits from the substantial base of academic and federal research being conducted in the state. As described above, TEDCO's role and mission are consistent with both the State of Maryland's economic development strategy and national best practices in state technology-based economic development. A brief description of TEDCO's main programs and available outcome measures is presented below.

TEDCO Research Programs

TEDCO's mission is to support the advancement of technology-based economic development in Maryland. With Maryland's strong base of academic and federal research, the state has only limited need to invest in basic research outside of the university system. However, Maryland has joined with several other states in supporting stem cell research. Stem cell research has emerged as one of the most important areas of basic research in the nation. As described in TEDCO's testimony before the Maryland Senate Subcommittee on Education and Business Administration:

> Stem cells have demonstrated tremendous potential to repair and replace damaged tissues and organs. Because stem cells are uniquely applicable to all types of diseases and injuries, pioneering research in this field could provide therapies for countless medical conditions, from Alzheimer's, Parkinson's, ALS, and sickle cell anemia to diabetes, heart disease, arthritis, severe burns, and spinal cord and bone injuries.

The fact that the 2012 Nobel Prize in Medicine was awarded to two stem cell researchers highlights the critical importance of this burgeoning field. Shinya Yamanaka, from Kyoto University, Japan, and John B. Gurdon, from the University of Cambridge, England, received the 2012 Nobel Prize for the discovery that mature cells can be reprogrammed to become pluripotent stem cells, able to differentiate into every cell in the human body (induced pluripotent stem cells or iPSC). This work laid new ground for regenerative medicine, rebuilding the body with tissues generated from its own cells.

The ***Maryland Stem Cell Research Fund*** (MSCRF) was established by the Maryland Stem Cell Research Act of 2006 to promote state-funded stem cell research and cures through grants and loans to public and private entities in Maryland, and is perpetuated through an appropriation in the governor's annual budget. TEDCO's MSCRF is one of seven state stem cell research programs identified nationwide by the National Institutes of Health. The other six programs are described below:[22]

- The California Institute for Regenerative Medicine was created in 2004 to fund stem cell research in that state, and has disbursed over $1.2 billion.
- The Connecticut Stem Cell Research Program was created in 2005, and has provided $78.6 million in stem cell research funding.
- The Illinois Regenerative Medicine Institute is a $10 million research effort.[23]
- New York Stem Cell Science (NYSTEM) and the New York Empire State Stem Cell Board were created in 2007 with a commitment of $600 million.
- The New Jersey Stem Cell Research Program was the first state stem cell research program, with initial funding for $10.7 million in research and $150 million for the construction of a stem cell research facility.[24]
- The Ohio Center for Stem Cell and Regenerative Medicine was created in 2003 with a $19.4 million award from the Ohio Third Frontier as a Wright Center of Innovation. It was granted an additional $8 million award in 2006 from the State of Ohio's Biomedical Research and Commercialization Program, and a $5 million award from Ohio's Research Commercialization Program in June 2009.

MSCRF has four main programs:

- **Pre-Clinical & Clinical Research Grants**, to be awarded for the first time in FY 2013, are designed for biotech companies interested in conducting pre-clinical and clinical human stem cell research in Maryland. For clinical applications, the company does not have to be based in Maryland, but at least one clinical site must be in Maryland in order to increase clinical trial activities at state universities and hospitals. Currently the MSCRF's largest award, each Pre-Clinical grant provides up to $500,000/year for up to three years, and each Clinical Research grant provides up to $750,000/year for up to three years.
- **Investigator-Initiated Research Grants** are designed for established researchers who have preliminary data to support their proposals. Each Investigator-Initiated Research Grant currently provides up to $600,000/year in direct costs, for up to three years. To date, the MSCRF has funded 47 Investigator-Initiated Research Grants.

[22] Not all of these programs are currently operating and several did not allocate all of their resources.

[23] http://nas-sites.org/iascr/about-iascr/iascr-participants/illinois/

[24] http://nas-sites.org/iascr/about-iascr/iascr-participants/new-jersey/

- **Exploratory Research Grants** are designed for investigators exploring new hypotheses, approaches, mechanisms, or models. Little or no preliminary data is required to support these applications. This program provides the opportunity for young investigators and established investigators from other fields to initiate or advance their careers by doing stem cell research. Each Exploratory Research Grant provides up to $100,000/year in direct costs, for up to two years. This funding mechanism frequently leads to future larger grant awards. To date, the MSCRF has funded 130 Exploratory Research Grants.
- **Post-Doctoral Fellowship Grants,** initiated in FY2008, are designed to recruit and train the best and brightest scholars early in their research careers, and to grow Maryland's stem cell research community. Each Post-Doctoral Fellowship Grant provides up to $55,000/year for research and salary, for up to two years. To date, the MSCRF has funded 81 Post-Doctoral Fellowship Grants.

The MSCRF's applications and awards are presented in Table 12. The total number of applications has increased from 85 applications in FY2007 to 171 in FY2013. The percentage of projects funded has fallen from a high of 51 percent in FY2008 to only 18 percent in FY2013. Since the creation of the program, TEDCO has received 1,027 applications for $436.0 million in research, but was only able to fund 295 projects for $100.5 million. The fact that the MSCRF has only been able to fund 29 percent of applications, representing 23 percent of requested funding, indicates there is substantial unmet need for funding of stem cell research projects.

Table 12: Maryland Stem Cell Research Fund Applications and Awards, FY2007 Through FY2013

MSCRF Program Activity	2007	2008	2009	2010	2011	2012	2013
NUMBER OF APPLICATIONS/GRANTS							
Applications	85	122	148	141	180	180	171
Investigated Initiated	41	33	38	20	42	31	32
Exploratory	44	65	70	77	97	105	92
Post-Doctoral	-	24	40	44	41	44	42
Pre-Clinical	-	-	-	-	-	-	5
Awards	24	62	59	42	36	40	31
Investigated Initiated	7	11	6	5	9	9	10
Exploratory	17	34	32	19	13	17	10
Post-Doctoral	-	17	21	18	14	14	10
Pre-Clinical	-	-	-	-	-	-	1
Percent of Projects Funded	28%	51%	40%	30%	20%	22%	18%
Investigated Initiated	17%	33%	16%	25%	21%	29%	31%
Exploratory	39%	52%	46%	25%	13%	16%	11%
Post-Doctoral	-	71%	53%	41%	34%	32%	24%
Pre-Clinical	-	-	-	-	-	-	20%
FUNDING AMOUNT OF APPLICATIONS/GRANTS							
Funding Applied For	$80,845,000	$62,076,562	$86,050,000	$52,550,000	$55,800,000	$50,380,000	$48,268,212
Investigated Initiated	$70,725,000	$44,838,714	$65,550,000	$30,000,000	$28,980,000	$21,390,000	$20,010,000
Exploratory	$10,120,000	$14,597,848	$16,100,000	$17,710,000	$22,310,000	$24,150,000	$20,930,000
Post-Doctoral	-	$2,640,000	$4,400,000	$4,840,000	$4,510,000	$4,840,000	$4,620,000
Pre-Clinical	-	-	-	-	-	-	$2,708,212
Funding Awarded	$13,997,810	$22,905,651	$18,938,685	$11,736,252	$10,682,833	$11,561,038	$10,705,723
Investigated Initiated	$9,430,157	$13,286,553	$9,328,970	$5,454,751	$6,182,833	$6,113,822	$6,812,268
Exploratory	$4,567,653	$7,749,098	$7,299,715	$4,301,501	$2,960,000	$3,907,216	$2,234,455
Post-Doctoral	-	$1,870,000	$2,310,000	$1,980,000	$1,540,000	$1,540,000	$1,100,000
Pre-Clinical	-	-	-	-	-	-	$559,000
Percent of Projects Funded	17%	37%	22%	22%	19%	23%	22%
Investigated Initiated	13%	30%	14%	18%	21%	29%	34%
Exploratory	45%	53%	45%	24%	13%	16%	11%
Post-Doctoral	-	71%	53%	41%	34%	32%	24%
Pre-Clinical	-	-	-	-	-	-	21%

Source: TEDCO

Stem cell research might be the most important emerging area of health and life sciences research, and it might have the potential to transform health care by curing or alleviating many of the world's most devastating diseases. The use of stem cells has facilitated the creation of a new medical field—regenerative medicine—with huge potential impacts on the treatment of disease. Unlike other areas of technology development where federal or private research spending funded the initial stages of basic research, state governments stepped in after federal restrictions were placed on stem cell research, and they have become a major source for stem cell research along with renewed federal and rapidly growing private sector research.

Why are states such as California, New York, Maryland, Connecticut, Ohio, and others investing in stem cell research? The answer is that the potential returns on the investment are large. The current domestic market for stem cells is estimated at over $1 billion, and the global market at over $4 billion. While this seems like a large market, it is currently small relative to the overall size of the entire healthcare and pharmaceutical markets, and thus has incredible room to grow. The stem cell industry expects to more than double over the next decade, and the potential payoffs to the states that grow, attract, and retain successful stem cell companies are immense. Maryland, as the home to the NIH, leading research universities, and other federal laboratories has the potential to be at the forefront of this industry. Maryland is a leading center for NIH funded stem cell research and is already home to over 70 companies involved in stem cells, including Global Stem, Neuralstem and Osiris Therapeutics, Inc. As the third largest state-funded stem cell research program in the nation, MSCRF seeks to develop, enhance and retain Maryland's stem cell research base and facilitate the creation of new research-driven stem cell companies.

Maryland is already a national leader in life sciences research. The state is ranked first in National Institutes of Health research and development contract awards and, according to the Pharmaceutical Research and Manufacturers of America, Maryland has the 9th largest biopharmaceutical sector in the nation. The state has correctly identified stem cell research as one of the most important emerging life sciences research areas and has targeted the growth and development of this emerging technology through the MSCRF. This investment is starting to pay dividends. While there is a lack of data on the overall size of the national stem cell research base, one measure of stem cell research activity is the level of NIH stem cell research funding. Based on data from the NIH for Various Research, Condition, and Disease Categories (RCDC),[25] Maryland has advanced from eighth place in NIH stem cell research funding in FY2009 with $40.3 million in funding, to third place in FY2012 with $114.4 million. During this period, overall NIH stem cell research funding increased by 11 percent, while Maryland's NIH funded stem cell research nearly tripled.

TEDCO Commercialization Programs

TEDCO's mission is to support the generation, transfer, and commercialization of technology. TEDCO's core technology transfer and commercialization programs seek to address the commercialization gap in Maryland by providing needed funding and technical assistance at each stage of the commercialization process.

TEDCO's newest program is the ***Maryland Innovation Initiative*** (MII). MII was started in FY2012, as a partnership between the State of Maryland and five Maryland academic research institutions—Johns Hopkins University, Morgan State University, University of Maryland College Park, University of Maryland Baltimore, and University of Maryland Baltimore County—to promote commercialization of university discoveries. The goal of the MII program is to foster the commercialization of university innovations through technology validation, market assessment, and the creation of start-up companies in Maryland. MII provides three phases of funding:

- **Phase I: Pre-commercial Research** – provides $100,000 (or $150,000 for a joint application between two universities) in funding for proof of concept and other studies on intellectual property that demonstrate the utility of a technology for a specific commercial application;
- **Phase II: Commercialization Planning** – provides $15,000 (or $20,000 for a joint application between two universities) in funding for commercialization planning such as the costs for

[25] Data are from http://report.nih.gov/categorical_spending.aspx and include grants where the state of performance is identified. Internal NIH research is not included.

purchasing a market analysis, for conducting market surveys, for contracting with industry experts, or for other costs associated with gathering and assembling the information required for the development of a proper commercialization plan; and

- **Phase III: Early-stage Development** – provides $100,000 (or $150,000 for a joint application between two universities) for corporate product development expenses to prepare for a product launch or the advancement of a product technology to achieve a commercial milestone that significantly increases the company's value and better positions the company for follow-on investment from angels or venture capitalists.

The MII also established Site Miners, individuals supported by the MII program to assist start-ups and faculty in the process of submitting a strong business-oriented application that is focused on commercialization. These individuals work as liaisons between the applicant and the MII program, providing valuable input and feedback prior to submission of an MII application. The MII program's applications and awards are presented in Table 13. TEDCO was only able to fund a total of 33 MII projects, or 37 percent, indicating unmet technology commercialization needs at the five participating universities.

Table 13: Maryland Innovation Initiative Applications and Awards

MII Program Activity	FY2013
MII Applications	89
MII Awards	33
Percentage Funded	37%
MII Amount Requested	$9,036,549
MII Amount Funded	$3,420,606
Percentage Funded	38%

Source: TEDCO

The Maryland ***Technology Commercialization Fund*** (TCF) provides up to $100,000 to support companies that advance a technology toward commercialization and adoption. TCF enables companies to achieve early technical milestones that are critical to move technologies further along the commercialization and adoption pathway and lead to follow-on investments. Three types of organizations are eligible to participate in the TCF program:

- A company with an active license or research agreement in place with a Maryland university, a federal laboratory that has a partnership agreement with TEDCO, or another non-profit research organization in the state;
- A company affiliated with one of Maryland's qualified incubator programs; and
- A company that has received mentorship from one of the TEDCO-supported, entrepreneurial development programs

TEDCO uses the TCF program to make investments in these organizations, enabling them to reach a critical milestone in their product (or service) development efforts that will move technologies further along the commercialization pathway, increase a company's valuation, and lead to follow-on investment and job creation. Investments through the TCF program are made in the form of a five-year, convertible note to the company. As presented in Table 14, TEDCO invested in 22 TCF projects in FY2013. TEDCO invested in a high of 61 percent of the companies that applied in FY2005, falling to a low of 22 percent in FY2012, and increasing to 34 percent in FY2013. Over the past five years, TEDCO has only

had sufficient funding to invest in about one-third of the organizations applying for TCF funding, again indicating unmet need for commercialization financing in Maryland. TCF has been a vitally important source of capital to address the "Valley of Death" that hinders commercialization in Maryland. ***The TCF program has supported the creation of a portfolio of 216 successful technology companies based on new technologies generated in Maryland that have gone on to receive $601 million in downstream funding to further support the development of TCF companies, more than ten times the level of state TEDCO funding for the program.***

Table 14: Technology Commercialization Fund Applications and Awards

TCF Program Activity	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Applications	22	44	52	88	70	68	67	59	82	58
Awards	13	27	27	34	27	22	21	17	18	20
% Awarded	59%	61%	52%	39%	39%	32%	31%	29%	22%	34%

Source: TEDCO

The **Technology Validation Program** provides funding to validate a technology for a specific application and/or to validate the market opportunity for a technology. The goal of the Technology Validation Program is to foster the creation of more start-up companies based on technologies developed at Maryland's universities, not-for-profit research institutions, and federal laboratories. The program is focused on universities and federal laboratories that are not part of the MII program. The validation of a technology for a specific application generally involves a small proof of concept study to demonstrate that the technology works as intended. The validation of a market opportunity generally involves a market analysis that demonstrates that products based on the technology will have a clear competitive advantage and meet a clear need in a significant market.

The Technology Validation Program includes two distinct phases—the Technical Assessment Phase and the Market Assessment Phase. The Technical Assessment Phase consists of awards of up to $40,000 for proof of concept studies at a Maryland university. The Market Assessment Phase consists of awards of up to $10,000 for a market analysis for a technology and for the development of a commercialization plan. Since its creation in 2013, the Technology Validation Program has received five applications and funded one project.

Universities and not-for-profit research institutions in Maryland are eligible to apply for both phases of the Technology Validation Program provided that they are not an active Qualifying University as defined in the Maryland Innovation Initiative statute. Entrepreneurs considering the creation of a Maryland-based start-up company relying on a technology from an eligible university, a not-for-profit research institution in Maryland, or a federal lab in Maryland for its formation are eligible to apply directly for the Market Assessment Phase of the Technology Validation Program.

The Maryland Innovation Initiative and the Technology Validation Program replaced two earlier TEDCO programs:

- The ***University Technology Development Fund*** (UTDF), which facilitated the commercialization of university technologies by providing early-stage funding of up to $50,000 to assist university innovators in increasing the attractiveness of their research to outside companies that may be interested in licensing the technology at a later stage; and

- The ***TechStart Program,*** which provided funding to universities to evaluate whether selected technologies or technology packages would have sufficient scope and potential to be the basis of a start-up company formed to commercialize the technology.

As described in the economic impact analysis section above, the MII program is too new to measure its economic impacts in terms of jobs and companies created, but outcome measures for its predecessor programs, UTDF and TechStart, do exist. According to data provided by TEDCO:

- Over its lifetime, the UTDF received 206 applications, awarded 115 projects, and 105 projects were completed;
    - Forty-four of the UTDF's projects resulted in a technology licensed to the private sector, with 36 of these licenses granted to Maryland companies;
    - Of the 44 technologies licensed, 35 were licenses granted to new start-up companies, 30 of which were located in Maryland; and
- Over its lifetime, TechStart received 71 applications, awarded 39 projects, and 37 projects were completed. Twenty-eight of TechStart's projects resulted in licenses granted to a start-up companies, all of which were located in Maryland.

The ***Patent Assistance Program*** provides matching funds to help start-up companies pay on-going patent expenses for technologies licensed from Maryland's universities or NIH. The program addresses one of the problems that entrepreneurs have when licensing a technology from a Maryland university or the NIH: shortly after a start-up company completes a license agreement with a university, the company can begin to incur on-going patent related expenses under the license before it has had time to raise funds to pay those expenses. Universities themselves have constrained patent budgets and must consider an entrepreneur's ability to pay ongoing patent expenses before engaging in license negotiations. The Patent Assistance Program addresses this problem by providing funds to the start-up company to help them pay on-going patent expenses while they are raising funds. The program will also incentivize universities and the NIH to license technology to entrepreneurs who have not yet completely financed their businesses. Since it was created, the Patent Assistance Program has funded six out of eight applications.

Entrepreneurial Support Programs

The technology commercialization process does not end once a technology is transferred to a start-up or existing company. Successful technology commercialization requires a technological innovation as well as the entrepreneurial/managerial talent to manage, and the risk capital to finance, the creation of the new company, product or service. TEDCO provides assistance in these areas as well.

Maryland's technology commercialization potential is not located only along the I-95 Corridor that links the state's major public and private research universities and federal laboratories. Maryland possesses strong research and technology generation opportunities across the state, not just in its colleges and universities but also in its technology-oriented businesses base. In order to tap this potential, TEDCO established the ***Rural Business Innovation Initiative*** (RBI2) to provide technical and business assistance to start-up and small technology-based businesses in the rural areas of Maryland, as defined by the Rural Maryland Council. The goal of the program is to help companies overcome business and technical hurdles and advance to the next growth level. There is no cost to the company to receive assistance.

Assistance to companies is provided by a regional RBI2 mentor. Each region has a local RBI2 business mentor, whose job is to evaluate potential clients and to provide resources, consulting services, and

technical management assistance. Mentors work closely with company clients at their business. The types of business assistance provided include:

- Business model or strategy;
- Market strategy/analysis and competitive analysis;
- Funding opportunities and introductions;
- Financial analysis;
- Business plan or grant review;
- Intellectual property;
- Prototype development; and
- Manufacturing problem solving.

In order to eligible for the RBI2 program, businesses must (1) be involved in developing new technologies/products or utilizing technology to create or expand their businesses, (2) have fewer than 16 employees, and (3) have annual revenues of $1 million or less.

Since the creation of the RBI2 program, TEDCO has met with 597 companies, mentored 423 companies and funded 51 technical assistance projects with 43 different rural companies, providing $323,659 in project funding. Some examples of RBI2 successes are as follows:

RBI2 Performance Metrics (FY2010-13)	
Companies Met	597
Companies Mentored	423
Number of Projects Funded	51
Number of Companies Served	43
Amount of Project Funding	$323,659

- **Glycopure, Inc**., which is located in Dorchester County, was successful in utilizing the MdBio biotechnology tax credit program to raise $700,000 in new capital investment after receiving assistance from the RBI2 program.
- **Spessard Mfg** (Valley Industrial Plastics) has been one of the most successful RBI2 companies and has received a $100K Phase II Maryland Industrial Partners (MIPS) award for home plate testing and a $500,000 loan from the Maryland Department of Business and Economic Development for a new building and working capital.
- The RBI2 Program has assisted several companies to participate in other TEDCO programs, for example the **i-lighting** company in Cecil County was awarded TCF funds of $100,000 and **TimberRock**, in Western Maryland received a $75K TCF loan award. RBI2 companies have also participated in the MIPS, Maryland Energy Administration, and other state economic development programs.

TEDCO also links Maryland technology companies with local entrepreneurial talent through the ***Maryland Entrepreneurs Resource List*** (MERL) program which connects a list of 85 seasoned entrepreneurs who have experience in venture capital finance, technology commercialization, business development, and other skills to early-stage companies to mentor or provide leadership. A partial list of companies that have received assistance from the MERL program includes: AriVax; AccuStrata, Inc.; Clear Guide Medical, LLC; Cordex Systems, LLC; Differential Dynamics Corporation; Green Eyes, LLC; InfraTrac, Inc.; and Solar Fruits. Many of these companies have also participated in other TEDCO programs such as the MII and TCF programs, demonstrating that TEDCO provides ongoing assistance to its portfolio of companies. The MERL entrepreneurs also assist TEDCO in its other programs, serving as reviewers for applications to the MII and TCF program and assisting portfolio companies in seeking venture capital investment.

TEDCO has also played a critical role in developing and assisting the tenants of Maryland's business incubator network. Over its history, TEDCO has provided planning grants and assistance in obtaining capital funding to incubators in Maryland. It also provides assistance through the ***Incubator Business Assistance Fund*** to assist incubators and their tenants in obtaining consulting and/or training resources to

foster the development of tenant companies. TEDCO provides funding to qualified incubators to help them implement best practices for their tenant/affiliate companies. These funds can be used when business services are needed that cannot be provided by the incubator staff. The incubators utilize this funding to enhance their current service offerings. Business assistance funding may be used to hire an independent consultant to work with a specific company on a project or to provide training or services that will directly benefit the companies. For example, incubators may use these funds to help a company develop a business model or marketing strategy, retain legal services, create marketing collateral, update a business plan, engage a temporary CFO, or attend business training seminars. Funding may also be used to purchase software that helps tenant or affiliate companies in marketing or business development. Since 2006, the Incubator Business Assistance Fund has conducted 27 workshops with attendance of over 676 individuals representing over 130 different incubator firms.[26]

Not only does TEDCO provide financial and technical support to promote entrepreneurial development in Maryland, it promotes and publicizes entrepreneurship in general through its ***Innovation, Corporate excellence and Entrepreneurship*** (ICE) awards program. The ICE program recognizes outstanding businesses and individuals from TEDCO's diverse portfolio of seed and early-stage companies. The most recent ICE Awards celebration, held at the Sheraton Columbia Town Center, was attended by more than 200 representatives from TEDCO's portfolio companies and partnering organizations. The event featured demonstrations by TEDCO portfolio companies of their technologies and prototypes, networking opportunities, the awards presentation, and remarks by representatives from 2012 ICE award-winning companies. TEDCO not only supports entrepreneurial development in Maryland, but through the ICE awards it highlights the importance of entrepreneurial development in general and its portfolio of companies to the state's economy.

TEDCO Innovation, Corporate Excellence and Entrepreneurship (ICE) Award Winners 2011–13

Round	Award
2011 ICE Award Winners	
Oculis Labs, Inc.	Innovation
Integrated BioTherapeutics, Inc.	Company
Dr. Chuck Daitch, Akonni	Entrepreneur
2012 ICE Award Winners.	
Vorbeck	Innovation
BioFortis	Company
Mahi Reddy	Entrepreneur
2013 ICE Award Winners	
Remedium	Innovation
TRX Systems	Company
Robert Rashford, Genesis Engineering	Entrepreneur

Finally, TEDCO works to address the shortage of venture capital investment in Maryland through its role in ***TEDCO Capital Partners*** (TCP), which manages a family of specialized venture capital funds. TEDCO's innovative strategy combines funds focused on specific geographic, demographic or technology-based investment theses with centralized deal-flow management, due diligence, reporting, and compliance functions. TCP is structured as a traditional for-profit entity that manages each fund with the purpose of maximizing the return on investment of its limited partners' capital. TCP, through its association with TEDCO, provides its venture funds with unique access to university and federal research lab assets throughout the Mid-Atlantic region. When fully implemented, TEDCO Capital Partners will operate four investment funds:

- The Veterans' Opportunity Fund (VOF) invests in businesses that are started, owned, or managed by veterans of the United States Armed Forces, making it the only venture capital fund in the nation specifically targeted to veteran-owned businesses;

[26] Data were not available for all workshops.

- The Propel Baltimore Fund makes investments in early-stage technology companies located in or relocating into Baltimore City;
- The Orange Knocks Cyber Fund (OKCF) invests in companies with economically compelling, technology-enabled solutions to critical problems in cyber security, including services, products, and niche technology companies; and
- The Chesapeake Regional Innovation Fund (CRIF) invests in early-stage companies which intend to create significant commercial enterprises based on potentially game-changing technologies developed at the region's federal research labs and major research universities.

Summary and Conclusion – TEDCO's Role in Maryland Technology Generation, Transfer, and Commercialization

As described above, TEDCO provides a full menu of programs designed to support and facilitate the generation, transfer and commercialization of technology in Maryland. Not only does TEDCO generate the economic impacts described in the first section of this report, it provides a full range of services to address the "commercialization gap" identified in both the Maryland economic development strategy and in national reports on technology-based economic development in the states as hindering economic development in Maryland. TEDCO's programs provide needed financial and technical assistance along each of the key links in the Technology-Based Economic Development Value Chain, and provide financial and technical support in the critical "Valley of Death" that hinders commercialization. By numerous measures, TEDCO has been successful in these efforts:

- The Maryland Stem Cell Research Program has improved Maryland's national footprint in this important area of life sciences research and development, with Maryland advancing from eighth place in NIH stem cell research funding in FY2009 to third place in FY2012;
- The Technology Commercialization Fund has created a portfolio of 216 successful companies that have gone on to receive $601 million in downstream funding to further support their commercialization efforts, more than ten times the level of state funding for the program, has generated nearly $540 million in economic impacts in Maryland, and has supported 2,666 jobs;
- The Maryland Innovation Initiative and Technology Validation Program, and their predecessor programs, UTDF and TechStart, have supported the early-stage capital needs of new ventures seeking to commercialize the new technologies being discovered in leading Maryland universities and federal laboratories, have assisted in advancing 72 technology licenses, and have supported the creation of 58 new start-up companies;
- The RBI2, MERL and Incubator Business Assistance Fund all provide access to technical support and assistance to support entrepreneurial development in Maryland; and
- TEDCO Capital Partners assists in addressing the shortage of venture capital investment in the state.

Through these programs and efforts, TEDCO makes a clear and important contribution to improving the technology and entrepreneurial development ecosystem in Maryland. TEDCO's mission and programs are central to the State of Maryland's economic development strategy and consistent with national state technology-based development best practices.

COMPARISON OF TEDCO'S ROLE AND IMPACT TO OTHER TECHNOLOGY-BASED ECONOMIC DEVELOPMENT EFFORT EVALUATIONS

The economic and functional benefits accruing to Maryland from TEDCO's mission and operations are clearly impressive. A key issue in putting these figures in context is determining how they compare to available economic impact evaluations of similar state-level technology-based economic development programs across the nation. TEDCO has long compared itself to large-scale, state-level, technology-based economic development programs like the Ohio Third Frontier Program or the Pennsylvania Ben Franklin Partnership. Battelle has compared the results of this analysis of TEDCO to available evaluation materials on these and other technology-based economic development programs. [27]

Ohio Third Frontier

In September of 2013, the Battelle TPP updated a previous analysis of the economic impact and return on investment (ROI) of the Ohio Third Frontier (OTF) program. Some of the key findings of this analysis are as follows:

- Since 2009 OTF has invested in 1,080 companies either directly or through its technology intermediaries;
    - 65% of the portfolio is within one of the state's targeted opportunity areas;
    - 121 of the companies in the portfolio have created/retained 11 or more jobs as a result of the investment to date;
- This portfolio of companies has leveraged OTF investment by a factor of 4.6 (not including product sales);
- The OTF portfolio of companies has direct employment of 7,780, and when economic multiplier effects are included, support a total of 22,276 jobs in the state;
- OTF's activities have generated a cumulative $352.6 million in state and local government revenues, covering 54 percent of the cumulative amount of $653.1 million spent on the program;
- The ROI on the state's investment in OTF has averaged 12 percent over the 2009–12 period.

Ben Franklin Technology Partners

The *Achievement in Uncertain Times: The Economic Impact of Ben Franklin Technology Partners* report analyzed the economic impact of the Ben Franklin Technology Partners (BFTP) program over the 2007–11 period.[28] Started in 1982, the Ben Franklin program is one of the nation's oldest, state-level technology-based economic development programs. Some of the key findings of this report are as follows:

- Since its inception in 1983, BFTP has made more than 3,500 financial investments in Pennsylvania companies. Many companies in BFTP portfolio were at the earliest stages of development when they first sought assistance, a time when funding is most critical and most difficult to obtain. BFTP has often been the first institutional investor for firms, providing seed capital for initial product development and commercialization efforts.

[27] This section of this report is not a comprehensive analysis of or comparison of TEDCO's impacts to all national technology-based economic development programs. Such an effort would be a substantial undertaking in and of its own and was outside of the scope of this engagement. This analysis simply compares the impacts estimated in this report to readily available evaluation materials on selected and comparable state-level technology-based economic development efforts, many of which were prepared by the Battelle TPP.

[28] See http://benfranklin.org/wp-content/uploads/BFTP.PEL_exec-summary_Final.pdf.

- In addition to direct financing, BFTP provides other valuable services to promote technology development in Pennsylvania:
    - BFTP helps companies secure additional capital from other sources.
    - BFTP staff work with portfolio companies to address critical business issues, anticipate future opportunities and needs, and accelerate companies' paths to success. BFTP staff often coach the management teams of portfolio companies, providing business advice and guidance. In addition, BFTP links firms with a variety of expert service providers, including university faculty, accountants, attorneys, technical experts, market researchers, management consultants and other business professionals.
- Over the 2007–2011 period, BFTP generated 7,485 additional jobs in client firms and an additional 12,715 multiplier effect jobs for a total employment impact of 20,200 jobs.
- The Commonwealth of Pennsylvania received $358 million in additional state tax receipts as a direct result of BFTP investments in client firms. Another $144 million in state tax receipts flowed from related BFTP client services, for a total increase of $502 million in state revenue due to BFTP.
- New state tax revenue generated because of BFTP represents a 3.6 to 1 payback to the Commonwealth on its $137.7 million investment during that period.

Arkansas Knowledge Economy Initiatives

The Battelle TPP prepared an analysis of technology-based economic development programs in Arkansas as part of the *Arkansas Knowledge Economy Initiatives: Analysis of Progress and Recommendations for the Future* report, released in November of 2012.[29] According to this report:

- Over the FY2008 to FY2011 period, Arkansas averaged $12–$13 million each year in research support funding; and
- Programs were funded to accelerate the formation of emerging knowledge-based companies and position them for success at a level of approximately $3.5 million per year.

Based on Battelle's analysis technology-based economic development programs in Arkansas had the following outcomes, as these excerpts illustrate:

> "Knowledge-based economy initiatives focused on research have received $61.2 million in state funding from 2008 through 2011 and leveraged an additional $191.8 million in non-state support. This represents an impressive return on state dollars invested in research: for each $1 in state funding the Arkansas programs have leveraged an additional $3.14. The economic multiplier impacts related to leveraged non-state research funds amounted to $335 million in total economic output to the state, and supported 2,820 job years over the period 2008 to 2011."
>
> "More directly associated with new business development are the initiatives related to commercialization/deployment, entrepreneurial development, and capital/financial activities that Arkansas has advanced to date. Collectively, the 135 emerging companies participating in the knowledge-based economy initiatives since 2008 have generated 1,259 direct industry jobs. The economic multiplier impact of this job creation amounts to a total of 3,251 jobs throughout the Arkansas economy. These direct jobs are found in

[29] http://www.aralliance.org/?a=3137.

industries offering significantly higher wages than the private sector average wage in Arkansas—on average over $70,000 a year. This is more than double the $34,014 average annual wage of the private sector in Arkansas."

Connecticut Initiatives

A 2010 analysis of the Connecticut Innovations (CI) program, *The Economic Impact of Connecticut Innovations' Portfolio on the Connecticut Economy (FY1995–FY2008*) report found the following:

- CI Creates Jobs – CI's investments grew Connecticut employment by an average of 1,610 jobs each year from 1995 through 2008.
- CI Contributes to State Tax Revenues – The cumulative, net state revenue generated by CI's investment activity exclusively exceeds $209 million. This represents an average increase of $14.9 million in net state revenues every year.
- CI Brings Additional Outside Investment Into Connecticut – Connecticut's cumulative investment in CI of $106 million leveraged an additional $1 billion over the period studied from CI's investment partners. As a result, Connecticut's gross state product increased cumulatively by $3.6 billion, and by $258.5 million on average each year.

TEDCO and Other State Programs

It is quite difficult to directly compare the results of economic impact analyses of these different state technology-based economic development efforts. Each state implements and targets its technology-based economic development efforts differently:

- TEDCO spends approximately 20 percent of its budget on technology commercialization related programs for small businesses and 80 percent on the Maryland Stem Cell Research Fund;
- OTF spends its money on a wide range of programs ranging from research to seed funds;
- BFTP spent most of its money on funding both early-stage and established companies; and
- CI combined venture and working capital investments with funding for facilities;

Thus, each of the major technology-based economic development programs whose evaluation results were described above utilized their technology-based economic development funding quite differently. In addition, each of the evaluations used a different approach and was for a different time period:

- The Battelle analysis of TEDCO was for its annual impact based on its current research programs and entire portfolio of companies;
- The OTF analysis looked at that program's portfolio since 2009 over time;
- The BFTP analysis was for aggregate impacts over a five year period and the; and
- The CI report analyzed average jobs created.

The results of the different analyses are presented in Table 15, but, as described above, caution should be used in making any comparisons.

Table 15: Results of Selected State Technology-Based Economic Development Program Impact Studies

Item	TEDCO Total[1]	TEDCO - Non MSCRF'[1]	OTF[3]	BFTP[4]	CI[5]
Total	**$153,974,768**	**$52,374,768**	**$653,142,802**	**$137,700,000**	**$164,253,000**
Direct Jobs	1,225	1,166	7,780	7,485[6]	1,610[7]
ROI	8%	23%	12%	n.a.	n.a.

(1) Over the operational lifetime of the program, FY2002 01502013

(2) Costs and benefits associated with all TEDCO programs, excluding MSCRF

(3) Over the 2009–12 Period - Includes some previous expenditures that impacted post 2009 portfolio.

(4) Over the 2007–11 Period

(5) Over the 1995–2008 Period

(6) THE BFTP Job Figures are for the differential growth of companies in aggregate over the entire period and are not directly comparable.

(7) Jobs are average jobs per year.

Source: Battelle TPP analysis of selected studies.

While it is difficult to draw comparisons between these different studies because of the differing emphasis of each state program and the different evaluation methodologies used, some key relevant issues can be clearly identified from Table 15. Most importantly TEDCO's entire twelve year lifetime funding levels are either small or comparable to *four to five year* funding levels for key peer efforts, even when the MSCRF is included. For comparison purposes, TEDCO spent only $52.4 million over its lifetime and only $21.5 million over the past five years on all of its programs other than the MSCRF. This is a very small amount in comparison to OTF and BFTP and many other state-technology-based economic development efforts. Moreover, TEDCO's job impacts are comparable to other programs when adjusted for the overall level of funding, and quite high if MSCRF funding is excluded. It is clear from this analysis that Maryland under-invests in supporting technology-based economic development—a fact pointed out in the Maryland Economic Development Commission's state economic development strategy which reports, "For decades, Maryland has been known as a state that has all the economic development assets, but has not invested sufficient resources to make the best of them maximally effective." TEDCO's return on investment is comparable to the OTF rate, the only other study that estimated this in a comparable way, and again quite high when MSCRF is excluded from the calculation.

The Maryland Stem Cell Research fund is TEDCO's single largest program and accounts for approximately two-thirds of TEDCO's budget over the last five years. The importance of this investment is clear in terms of its role in positioning Maryland for future success in this critical scientific area. As presented above, the R&D activities associated with the Maryland Stem Cell Research Fund generate $19.9 million in economic activity in Maryland, support 128 jobs earning $8.9 million, and have an associated $0.8 million in estimated state and local government revenues. Over its entire lifetime, the MSCRF has funded 294 projects for a total of $101.6 million dollars, a small amount in comparison to California's stem cell research funding of over $1 billion and New York State's budgeted $600 million.

As with the analysis of technology-based economic development evaluations described above, Maryland has achieved strong results from its investment in stem cell research, which have helped maintain the state's position in this critical technology. Maryland is among the national

leaders in the level of state funds invested in stem cell research, but again lags key states such as California and New York.

IN CONCLUSION

TEDCO is a vital component of Maryland's economic development strategy and technology commercialization system. TEDCO was specifically created to address the gap between Maryland's leading national position in academic and federal research and development activity and much lower level of commercialization activity. The need to expand commercialization activity has been recognized by both national studies, such as the Milken Institute which reports that, "Maryland's weakness is in the risk capital and entrepreneurial infrastructure category, an area in which it has consistently underperformed" and in the state's own economic development strategy which reports that "Maryland's unparalleled research riches are not reflected in its commercialization track record." TEDCO was created to address this issue and has more than a decade of success in promoting technology generation, transfer and commercialization in a way that positively impacts the Maryland economy and improves the state's technology and entrepreneurial ecosystem. TEDCO, through the MSCRF, has spearheaded the expansion in Maryland's research footprint in this critically important area, expanding the state's stem cell research capacity and facilitating an improvement in Maryland's national position from eighth place in FY2009 to third place in FY2012.

While the economic contributions of TEDCO's operations are clearly impressive, they only represent a part of its contribution to Maryland. More important than the economic and fiscal contributions of TEDCO is its role in facilitating, supporting and enhancing the generation, transfer and commercialization of technologies in Maryland. TEDCO provides vitally needed funding and technical assistance at the critical links in the Technology-Based Economic Development System and during each step of the technology commercialization process.

TEDCO's programs are a vitally important source of both capital and technical assistance in a state that, despite its clear strength in research, lags its peers in both venture capital investment and academic technology transfer activity. TEDCO has funded 294 MSCRF, 228 TCF and 49 MII projects, but there is substantial unmet demand for TEDCO investment and assistance, with only 29 percent of MSCRF, 37 percent of TCF and 40 percent of MII applications funded over the entire history of each program. TEDCO generates economic impacts comparable to key best practice state technology-based economic development efforts, despite low levels of state investment in TEDCO's technology-based economic development support mission.