

DELAWARE SCIENCE, TECHNOLOGY AND ECONOMIC DEVELOPMENT

The purpose of this document is to provide a current perspective of science and technology based economic development in Delaware – active programs, new opportunities and potential threats – with the purpose of catalyzing collaborative partnerships among the academic, private and public sectors to improve the State’s competitive position and provide social and economic benefit.

Science and Technology in Delaware

Leadership in Science and Technology (S&T) has become both a State and national priority. This is necessitated by the development of a global knowledge-based economy and a shift to other countries of high labor content manufacturing and services. The pace of change in technology intensive businesses has dramatically increased caused by new scientific discoveries and entrepreneurial innovation.

As the mature industries of Delaware decline or shift strategies, new market opportunities emerge. They must be identified early and appropriately supported if Delaware is to become competitive, maintain a healthy environment and prosper. Economic growth will be driven by businesses and institutions that are on the cutting edge of science and technology. This requires a business environment that stimulates innovation, entrepreneurship, knowledge-based partnership and a high standard education system including workforce development.

The National Science Foundation's (NSF) Experimental Program to Support Competitive Research (EPSCoR) is an important federal program for eligible states to build science and educational capacity. Delaware has been designated an EPSCoR state. To participate in the EPSCoR program it is required that the EPSCoR grant proposal be consistent with the State's plans for S&T based economic development.

To meet this requirement, leaders from the public, private and academic sectors met and developed such plans. The following strategies were established:

- Select and nurture emerging S&T intensive business segments where the focus will be on developing a research and innovation base to create new partnerships, products, jobs and companies.
- Attract top scientific and entrepreneur talent to the State, capitalizing on the State's geographic compactness to build internationally recognized, multi-institutional centers of excellence in targeted fields.
- Better integrate S&T into the State's education systems to produce the quality workforce required of technology based businesses.
- Foster a culture of innovation, entrepreneurialism and knowledge-based partnerships among private, public and academic institutions state-wide, regionally, nationally and globally.

Going forward the State EPSCoR Steering Committee has assumed responsibility for updating and maintaining the State's plans for S&T development. The Committee which includes representatives from the academic, public and private sectors is chaired by David Weir, Director of the Office of Economic and Innovative Partnerships. The Committee has identified six critically important Sectors: The Environment, Human

Health, Sustainable Energy, Agriculture, Cyber Security and Innovation and Entrepreneurship. As reported below, strategic actions are already underway to respond to the opportunities and challenges in each Sector. For example:

Environmental

- Devise and develop an early warning system that gives emergency management officials up to four days advance warning of flooding events.

Human Health

- Pursue additional NIH funding opportunities to further develop the DHSA collaborative partnership.
- Relocate selected units of UD's College of Health Sciences to the STAR Campus
- Establish and develop the BADER Consortium.

Energy

- Demonstrate the technical and commercial feasibility of Grid Integrated Vehicles and decide on next steps to commercialization.
- Secure NSF funding to establish a Center for Electrochemical Science and Technology.
- Support Bloom Energy as required to establish a manufacturing facility based on 'lean manufacturing' at the STAR Campus.

Cyber Security

- Establish a task force with representatives from the public, private and academic sectors to recommend a program for research, education, and work force development in cyber security.

Innovation and Entrepreneurship

- Develop the entrepreneurial ecosystem – an integrated functioning network – that establishes Delaware as a center of innovation, entrepreneurship and technology based economic development.
- Design and carry out a second 'Spin In' pilot focused on Traffic Control and decide on commercialization.

Regional Opportunities

- Develop programs to take advantage of the economic development opportunities arising from the establishment of the Army's Research, Development and Engineering Command at the Aberdeen Proving Ground.

Agriculture

- Ensure that facilities for delivering critical services to agriculture are state-of-the-art.
- Apply unparalleled scientific advances for the benefit of agriculture.
- Strengthen collaborations with diverse partners both local and beyond our borders

Science and Technology Economic Development

The discussion of Delaware's S&T based economic development is organized into six Sectors. Each Sector contains a discussion of the relevance, an assessment of the established base, strengths and competitive position and actions currently underway. In each case, the goal is to build a statewide capability and derive social and economic benefit. There is some natural overlap between sectors that provides additional value but will require leadership interaction. Public, private and academic experts, in each of the Sectors, were consulted for their contribution and ongoing support.

1. The Environment

Relevance

Global climate change, land use change due to population growth, and air and water pollution are major environmental challenges facing Delaware. Environmental conditions have significant impact on quality of life and human health, as well as major Delaware industries, including tourism and agriculture. Ecosystem services, such as the state's water supplies provide a powerful engine for the economy, contributing up to \$6.7B, including more than 70,000 jobs, providing over \$2 billion in wages (Narvaez and Kauffman, 2012). Tourism, including beach resorts is the third largest employer in the State. It has grown to a \$2.1B industry, employing 39,000 people and attracting more than 7M visitors to Delaware each year. Agriculture, propelled by the large poultry industry, provides a total economic contribution of nearly \$8B to the State.

Delaware is the lowest lying state in the U.S. an average 60 feet above sea level. The state is vulnerable to Atlantic storms, and impacts of sea level rise (SLR) due to climate change. Sea level is rising faster in our region than other parts of the world (Sallenger, 2012), with significant projected impacts on the natural and built environment, including degraded wetland habitats that buffer floodwater, and saltwater intrusion effects on water. A large part of the state's infrastructure including factories, wastewater treatment plants, bridges, and roads are located in flood-prone and low-lying areas. The state is also faced with subsidence of coastal areas and failing century-old dikes. The latter issue impacts cities, such as historic New Castle and Delaware City, where the dikes also protect the two industrial sites contaminated with hazardous waste from tidal flooding. With climate change and the concomitant rise in sea level, there is also concern about the cycling and transformations of soil contaminants. In Delaware alone, more than 700 contaminated sites comprise 60,088 acres of land. In New Castle County, where over 70% of the State's population resides, there are more contaminated sites per square mile than all but three counties in the U.S. Furthermore, the vast majority of the contaminated areas are clustered near communities comprised mostly of low-income earners and minority populations. Consequently, in addition to adaptation challenges, there are associated policy and environmental justice issues.

Despite effort to enhance the water quality in the State, there are still quality issues due to excessive nutrients such as nitrogen and phosphorous attributed to agricultural runoff from farms, wastewater treatment plants, and storm water runoff and air pollution deposition. The excess nutrients cause oxygen depletion that result in fish kills and algal blooms.

Established Base

Through a strategic planning process, UD has identified environmental science as key research and education thrusts. Also the Delaware Environmental Institute (DENIN), to serve as a catalyst for research, education, economic development and policy solutions to our most pressing environmental problems. In parallel an industry coalition, the Delaware Sustainable Chemistry Alliance, was formed in 2011, with leadership by Ashland and DNREC's support, to foster new process and product technology development and job growth, sensitive to the State's environmental issues.

Strengths and Competitive Position

UD has made a major investment to support cutting-edge environmental research that will benefit the State in the new UD Interdisciplinary Science and Engineering (ISE) Laboratory. The facility will house DENIN, the UD Energy Institute and related energy and environmental policy research centers, and the core instrumentation laboratories. Since 2008, UD has hired a diverse group of 11 new environmental faculty. Additional hires planned, including an endowed chair, will bring the UD environmentally related faculty community to over 100.

Delaware has received funding from NSF through the EPSCoR proposal (with matching State program funding of \$32M) focused on environmental science and education. As a result a strong partnership among Delaware's academic institutions and State agencies has developed which has attracted an additional \$56.5M of federal funding for improved academic environmental research and education infrastructure in areas of science and engineering. To support this as part of the fund raising stream, Delaware secured one of six NSF Critical Zone Observatory grants for \$4.3M to study carbon cycling in terrestrial and aquatic systems and impacts on climate change. Also two EPSCoR Track-2 awards were awarded for \$2.2M to implement key cyber infrastructure improvements across campus and the State as part of a five-state Northeast Cyberinfrastructure Consortium (NECC).

Action Underway

Delaware Technical and Community College (DTCC) has established the Center for Industry Research and Workforce Alignment (CIRWA), funded through the US Department of Labor, which will provide data to drive workforce training decisions in critical sectors such the environment and energy.

EPSCoR and DENIN have joined forces with DNREC and the Delaware Emergency Management Agency to devise an early warning system that gives emergency management officials up to four days advance warning of flooding events. The project incorporates innovative sensing technologies and integration of diverse environmental observations to help in the mitigation of damage from coastal flooding along Delaware's coastline. DENIN and EPSCoR have also launched a graduate-level environmental science and policy internships with DNREC and DNS.

The Delaware Nature Society (DNS), one of the State's premier environmental public advocacy and education nonprofit organizations, is a partner in the EPSCoR RII-C2 grant with a program that will significantly enhance their capability for cyber-based environmental education enrichment to a broad base of Delaware students.

Other actions include:

The Delaware Nutrient Management Program which develops guidelines and regulations on nutrient management and waste management associated with animal feeding to enhance water quality.

The Delaware Sea Level Rise Committee is charged with developing an adaption plan and recommendations for State agencies, local governments, businesses, and citizens for dealing with the impacts on sea level rise.

2. Human Health

Relevance

The institutions that deliver health care, and the numerous companies related to this industry, make the Human Health sector the largest employer in Delaware. The Christiana Care Health System (CCHS) is one of the largest clinical hospitals in the country. Nemours/A. I. DuPont Hospital for Children (Nemours) specializes and excels in pediatrics. The Delaware BioScience Association (DE Bio) has 120 members, offers extensive networking and educational events and is very engaged in education at all levels. DE Bio has a leadership role in the national Biotechnology Industry Organization, BIO. Delaware's industrial base is diversified in therapeutics, diagnostics, devices, contracted services and cutting edge research.

As part of an industry-wide shift in the pharmaceutical industry, Astra Zeneca (AZ) has ceased R&D in Delaware although it continues to make acquisitions and alliances to rebuild its pipeline as blockbuster products come off patent. As a result of the pharmaceutical downsizing there is increased outsourcing to companies in Delaware such as QPS, Wilmington PharmaTech and SDIX.

In the device market several companies are growing in Delaware. For example W.L. Gore views medical products as one of its most important businesses. The

development of exciting device, diagnostic and instrument products based on lasers, software, electronics and assays are underway at B&W Tech, Lite Cure, Thermo Fisher NanoDrop, Siemens, ANP Technologies, Agilent, DuPont Qualicon, MIDI, CD Diagnostics, Adesis and others in Delaware.

Established Base

Over the past decade, Delaware has successfully enhanced its biomedical research capability by taking full advantage of the institutional networking, research collaboration, and infrastructure-building initiatives supported by the NIH Institutional Development (IDeA) program. The State has been awarded over \$120M by the NIH-IDeA program. Under this program, Delaware launched the statewide IDeA network of Biomedical Research Excellence (INBRE) in 2001. The program is led by UD, with two academic health care institutions – CCHS and Nemours – and three academic institutions – Delaware State University, Wesley College, and DTCC- as partners. In addition, Delaware institutions have successfully competed for four IDeA centers of Biomedical Research Excellence (COBRE) programs, three at UD and one at Nemours, focused on membrane science, osteoarthritis, biomaterials, and pediatrics, respectively. A strong statewide biomedical research network has developed, leading to remarkable institutional changes and significant improvements in biomedical research at each of the partner institutions.

To further enhance biomedical research and education across the Delaware Valley, the Delaware Health Sciences Alliance (DHSA – www.dhsa.org) was established in 2009, among three Delaware INBRE partners – UD, CCHS and Nemours – and Delaware's Medical School, Thomas Jefferson University, located in Philadelphia, PA. The DHSA combines the priorities and assets of its partners, provides leadership in improving regional health, and provides a key stimulus to the region's economic future by nurturing research and the development of advanced technology. The DHSA advances health care education by advocating interdisciplinary undergraduate and graduate training programs through the Partnership in Health Education. DHSA works closely with several research centers including the Delaware Rehabilitation Institute (DRI), the Center for Biomedical Engineering Research (CBER), the Center for Translational Cancer Research (CTCR), the Delaware Cardiovascular Research Center (DCRC) and the Delaware Biotechnology Institute (DBI).

Despite the absence of a medical school, Delaware has created an outstanding reputation in one particular medical area, both for basic and clinical and translational research – Rehabilitation Sciences. Rehabilitation sciences accounts for about one third of the annual NIH funding secured by Delaware institutions. UD's graduate Physical Therapy program is ranked 4th in the nation. The goal of UD's three COBRE programs, led by Thomas Buchanan, Ph.D. is to create the infrastructure and expertise base to address the mechanisms, prevention, and treatment of osteoarthritis.

Strengths and Competitive Position

The focus of DHSA is on clinical and translational research, new concepts for health care delivery, reduced health care costs, professional training and the development of an infrastructure of skilled professionals and state of the art facilities and equipment.

Through the INBRE grant, UD, DSU, DTCC and Wesley are partnered in many life science programs as part of the statewide biomedical infrastructure.

Recently CCHS launched the Value Institute, a major initiative designed to achieve more coordinated health care and produce greater value in cost, quality and patient satisfaction. Total engagement by all functions of CCHS is required and rigorous data collection and metrics are critical to success. In April 2012, two of the DHSA institutions received major awards (out of 107 in the nation) from the Center for Medicare and Medicaid Innovation (CMMI) through the agency's Health Care Innovation Challenge. CCHS, under the leadership of William Weintraub, MD, was awarded \$10M for a project focused on improving post-myocardial infarction and revascularization of patients, while Nemours, under the leadership of Mary-Kate Mouser, M.Ed., received \$3.7M to investigate childhood asthma.

At UD, new investment in design and construction is underway to relocate selected departments and centers of the College of Health Sciences to UD's STAR Campus, with a special focus on clinical physical therapy and rehabilitation. The Department of Defense (DOD) has awarded a \$19.5M grant to a group of orthopedic researchers led by UD to help wounded warriors return to active duty or function in everyday life. The BADER (Bridging Advanced Development for Exceptional Rehabilitation) Consortium brings together military training facilities, academic researchers and rehabilitation institutes. A \$3M grant was awarded by the DOD's Advanced Research Project Agency to UD's Center for Composite Materials (CCM) to work with BADER to develop improved and lower cost orthotic and prosthetic devices

A five year collaborative agreement between the Fraunhofer Center for Molecular Biotechnology (FhCMB), the State and UD for development of vaccines and therapeutics from plant systems was executed in 2011. FhCMB has entered clinical trials for new drug development for both avian and pandemic influenza.

Incyte has FDA approval for commercialization of Jakafi, a drug for treatment of myelofibrosis (blood cancer). The company also has a valuable pipeline of potential drugs and partnerships with several large pharmaceutical companies. The size of the workforce has tripled to 300 since the decision to start the company in DE.

Action Underway

Human Health is the strongest sector and the largest growth opportunity for Delaware's economy. In the absence of an in-state medical school, the focus is on health sciences and builds a statewide infrastructure providing social and economic benefit including job creation.

The current areas of emphasis encompass:

- UD leadership for continued development of the DHSA collaborative partnership. Additional NIH grants will be sought; for example the Delaware Clinical and Translational Research Program (CTCR) and Center for Translational Science Award (CTSA).
- Submission of a proposal for a third NIH-INBRE Award in June 2013 will be made to further build the biomedical research and education capacity in the State.
- Relocation of selected departments and centers of UD's College of Health Sciences to UD's STAR Campus with the center piece being clinical physical therapy and rehabilitation.
- The establishment and successful development of the BADER Consortium including collaboration with the Army's Edgewood Chemical and Biologic Center (ECBC) part of the Army's Research Development and Engineering Command at Aberdeen Proving Ground in MD.
- A new interdisciplinary Biomedical Engineering program at UD
- COBRE funding of \$8 to 10M is pending for a new Center for Neuroscience Research at DSU.

3. Sustainable Energy

Relevance

In 2008-9 a comprehensive new State Energy Plan was requested by DNREC and submitted to the Governor's Energy Advisory Council. As part of this effort, the Supporting and Growing Delaware's Clean Energy Businesses Workgroup was formed which included large and small energy related companies, state and local government, universities and colleges, utilities and others from the community. This section updates the development and commercialization of renewable energy sources and the conservation of energy for cost savings and reduction of environmental impact. The State has an aggressive Renewable Portfolio Standard requiring 25% of its electricity be produced from renewable sources by 2025 (4% of it from solar).

Established Base

Two primary themes of the global, national, and local energy markets are the conservation of energy and replacement of carbon based sources for fuel and power with renewable forms of energy. There are some major issues that have mitigated the adoption of renewable sources of energy. The federal and local regulatory and financial incentives for specific technology deployment remain in constant flux. The prolonged recession, the discovery of vast amounts of domestic shale gas and new drilling for oil have caused significant price drops further weakening political will to legislate a shift from hydrocarbons. Never the less Delaware is a leader in the S&T of renewable energy and is well positioned for commercial adoption.

Strengths and Competitive Position

Economic development continues steadily in solar photovoltaic and biofuels but there is unique new emphasis in development of fuel cell systems and electric vehicles and their coupling to the grid for power management. Strategic relationships with UD, the State and Delmarva Power have been formed with Bloom Energy to manufacture proprietary fuel cell systems on the STAR Campus and purchase electric power. Initial plans are for Bloom to hire 900 employees plus the potential for another 600 jobs later from suppliers.

NRG entered into a joint venture agreement with UD's proprietary technology to integrate electric vehicles with the grid for both charging and storage to provide economic options to help balance input and distribution demands on the grid. In 2011 Professor Yushan Yan, a world class researcher in fuel cells, accepted an offer from UD and moved to DTP with his entire fuel cell team. His unique technology is much lower cost than conventional systems and the basis for a proposed new national NSF Science Research Center, Center for Electrochemical Energy Science and Technology. Professor Yan's proposal has passed Step 1 of the approval process and is one of only ten proceeding to Step 2 review by an NSF evaluation team.

The Delaware Sustainable Utility (SEU) was established using bonds as investment incentive for consumers to adopt energy conservation. This is a unique model to Delaware. Federal stimulus was used to increase the investment available but those funds are now gone. Going forward DNREC, Delmarva Power, and the SEU seek to work collaboratively to help both large public sector users and residents with conservation incentives.

Despite the uneven pace of federal support for offshore wind and the consequent cancellation of the NRG Bluewater – Delmarva Power power purchase agreement, offshore wind power remains the lowest cost potential renewable energy source available today in Delaware. While the near term commercial opportunity is deferred, NRG continues to pursue a federal lease for the project and several significant research projects are planned or underway in Delaware. A research and development partnership between UD, Gamesa and others is taking place at the wind turbine in Lewis, DE. In addition, UD is leading an engineering study to reduce the cost of offshore wind power by 25% and

participating in partnerships in studies on grid integration of offshore wind and characterization of winds offshore. Finally, building on a UD-prepared marine spatial planning report, UD, Cornell, the National Renewable Energy Lab (NREL), and a dozen private parties have proposed to build a ground-breaking test site off the Delaware coast to prove several new large-scale offshore wind turbines. In response to a DOE Funding Opportunity Announcement – Offshore Wind Advanced Technology Demonstration Projects, UD has submitted an application in the category “United States Offshore Wind Innovation and Research Center. The submission successfully passed Step 1 of the review process and will now proceed to Step 2.

Significant federal research grants have been awarded to advance renewable energy technology development. The UD Energy Institute was established to leverage and oversee the individual progress. UD has established several commercial sector partnerships in wind, electric vehicles, electric grid management and fuel cells to exploit new intellectual property. DTCC launched associate degree programs in a partnership with Lane Community College in Energy Management and Renewable Energy – Solar. DTCC built the Innovation and Technology Center to provide hands on training for careers in energy conservation and renewable energy. In 2011 UD won a federal Energy Frontier Research Center grant for \$17.5M to develop new technologies to convert biomass to fuels and chemicals.

DuPont is a global leader in developing the value chain from agricultural carbohydrates to biofuels and biomaterials. In 2012 DuPont announced the \$7B purchase of Danisco, the second largest maker of enzymes to create biofuels. While manufacturing is not likely in Delaware, considerable R&D will be conducted at the Experimental Station. Ashland has expanded its biomaterials and bioprocessing research and development capabilities in Delaware.

Action Underway

Develop new opportunities for research, development and testing partnerships to position Delaware position itself for future participation in solar, wind, electric vehicle systems, fuel cells and biofuels. Each of these development programs will be pursued with the help of federal grants and industrial partnerships. For example UD and State resources will be devoted to Bloom Energy’s manufacturing plans for lean manufacturing and workforce development to assure a successful start-up and sustainable business. The NRG/UD joint venture will complete the Grid Integrated Vehicle test program and decide on further scale of commercialization. Emphasis will be placed on securing NSF funding for a UD Center for Electrochemical Energy Science and Technology.

4. Cyber Security

Relevance

As reported in a University System of Maryland Task force on Cyber Security “In today’s globally interconnected communications and information environment, cyber security is necessary to ensure critical support for the U.S. economy, civil infrastructure, public safety and national security”.

Cyber security consists of multidisciplinary skills, processes, technologies, capabilities and services that stem from computer information and network security. The technology encompasses software and hardware tools, techniques and risk management processes that assure the confidentiality, integrity and availability of data and systems, thus providing the means to store and share information without undue risk of unauthorized disclosure, loss, or modification.

Established Base

Building a strong research and educational capability in this area is a top national priority. The US military began its cyber buildup in 2008 with the creation of a formal US Cyber Command to rapidly develop and deploy offensive and defensive capabilities. Cyber Security has become a mission critical commitment for the Army’s Research, Development and Engineering Command (RDECOM) an important partner of UD that is located at the Aberdeen Proving Ground (APG) in Maryland. It is also important for Delaware’s future, where several large employer groups, including the Financial Services industry centered in Northern Delaware, will require technologies and a trained workforce to remain competitive.

Competitive Position

Currently Delaware is lagging behind.

The State of Maryland has made significant investment to build a leading capability in this strategically important area. The University of Delaware, in partnership with DTCC and Harford Community College in Maryland, with support from SAIC and RDECOM’s CERDEC unit, has been awarded a grant by NSF to establish an educational program as a first step to build a research, education and work force capability in this important area.

Action Underway

It is proposed that the College of Engineering, in partnership with OEIP, convene an advisory group, composed of leaders from the public, private, government and academic sectors, who are knowledgeable in this arena and who can help define a focus of differentiation and an approach, resulting in an integrated program whereby Delaware can achieve a competitive position within three years.

Interest in participating in such an exploratory team has been expressed by SAIC, JPMC, RDECOM-CERDEC, the State of Delaware and UD's academic partners including DTCC and Harford Community College.

5. Innovation and Entrepreneurship

Relevance

For decades Delaware was known as the “corporations” state and enjoyed a robust and diverse economy. That began to seriously erode at the turn of the 21st century with global competition, manufacturing site closings, divestitures, acquisitions and workforce downsizing.

A much different ecosystem is needed if the future Delaware standard of living is to recover and be sustainable. In 2004 business, academic, and public sector leaders met with the Council on Competiveness to explore ideas as to how the challenge could be met. Two imperatives were agreed upon:

1. Develop an entrepreneurial ecosystem and culture that fosters and values early stage companies with supportive networks, policies and resources.
2. Encourage UD to take the lead to accelerate the innovation and knowledge economy and make it a priority to reach out to the private and public sectors.

Over the past five years significant steps have been taken and with measurable progress as reported in earlier Sections of this document.

Established Base

First State Innovation (FSI), a 501.c.3 nonprofit, was established in 2006 to help grow, attract, retain and facilitate high growth technology based businesses and supporting infrastructure in the State. In short, the goal is to connect people, ideas and capital. FSI's leadership is comprised of senior executives from science based companies and financial institutions, the presidents of Delaware's universities and colleges, the Delaware Economic Development Office (DEDO), venture capitalists and CHHS.

As earlier discussed, UD established OEIP to lead its economic development role as a Tier 1 Land, Sea and Space Grant university. OEIP's mission is to develop and market the UD's knowledge-based assets for social and economic benefit of the University, the community, the State and the region, by establishing partnerships that engage the assets and capabilities of the UD.

With the purchase of the Chrysler Assembly Plant and its transformation to the UD's STAR Campus, the DTP and STAR Campus are excellent locations for knowledge based companies and institutions to launch and grow. In 2012 DTP has 50 early stage companies and institutes and has spun out another 30 to the community over the last 15 years directly impacting 16,000 new jobs. Collectively enterprises in DTP have been awarded nearly \$300M in grants and contracts.

Strengths and Competitive Position

Since 2008, FSI, DTP and OEIP, in partnership with DEDO and a number of private sector entities, have adopted a collaborative goal of establishing an integrated 'Entrepreneurial Ecosystem in Delaware. The elements of the Ecosystem would encompass a continuum of funding, a supportive infrastructure (legal, education programs, finance, business planning, etc.) and incubation space with access to laboratory facilities and equipment, meeting areas, faculty and interns.

Significant progress has been made in developing the Ecosystem. For example; OEIP has established an integrated business development capability by merging UD's Technology Transfer Center (patent procurement, licensing, etc.) with Delaware's Small Business and Technology Development Center, Delaware's Procurement and Technical Assistance Center and the DTP. This organization fully integrates invention discovery, intellectual property acquisition, technology transfer and new business development into a seamless economic development unit with enhanced operating capability and broad state and national networks.

An important element of the Ecosystem is the development of sustainable, mutually beneficial partnerships with technology-based entities interested in accessing UD's knowledge-based assets (faculty, staff, students, facilities, IP, instrumentation, etc.), with the potential of establishing a presence in Delaware particularly at the STAR Campus. Through outreach marketing of UD's assets OEIP has established, or is participating in, a portfolio of Spin Out of UD's start-ups (ET International, Evozym, Elcriton), Spin In of private sector technologies for development and subsequent Spin Out, joint ventures (Grid Integrated Electric Vehicles with NRG), licenses with private sector entities (Becker Underwood in seed treatment technologies and Molnycke in puncture resistant surgical gloves) and a major collaboration with the Army's Research Development and Engineering Command (RDECOM) at the Aberdeen Proving Ground (APG) in MD.

To address the continuum of funding issue, OEIP has established a 'Proof of Concept' fund to allow the demonstration of the commercial potential of UD's scientific discoveries. Also discussions are being held with the State to include in the funding continuum State Bridge and Pre-commercial funding. FSI has undertaken the organization of a Delaware based, independent, professionally managed Angel Fund with a minimum goal of \$5M for Series A investments in high potential early stage companies primarily in Delaware.

For the past decade, UD's Lerner College of Business and Economics has conducted an academic minor in entrepreneurship, conducted a Business Plan Competition and more recently established a Venture Development Center. In 2008 OEIP joined with Lerner College and the College of Engineering to broaden the scope and reach of the Lerner program to include broad campus participation and to introduce other program elements such as a forum on entrepreneurship and an Entrepreneur in Residence event.

UD's Lerner College has launched a new gift supported endeavor named the Horn Program in Entrepreneurship with the mission to foster innovation and entrepreneurship, provide new educational opportunities and catalyze the entrepreneurial ecosystem. The Horn Program will be active both on and off campus with an emphasis on experiential learning, two-way engagement with alumni and the community and partnerships with service providers, investors, and other key stakeholders. The premier offering will be the startup experience program available to top students across UD and used as the centerpiece for the establishment of an undergraduate major and a doctoral minority in entrepreneurship and technology commercialization.

DTP is fully occupied with very promising companies and has space to add one large or two small buildings to complete the site. The STAR Campus is under development and already shows evidence of contributing to the State's economy. Both locations need additional incubation space, particularly wet laboratories required by companies in the life sciences, renewable energy and advanced materials. Space to participate in classified research is also a requirement.

Action Underway

OEIP, FSI and DEDO will intensify efforts to develop the Ecosystem into a functioning, integrated network, that establishes Delaware as a center of innovation, entrepreneurship and technology based economic development. Particular emphasis will be placed on the continuum of funding, the development of the STAR Campus and the creation of additional incubation space. OEIP, COE and the Lerner College will conduct a second Spin In pilot based on Traffic Control and decide on establishing a formal program.

6. Regional Opportunities

Considerable potential for economic development exists in the regional corridor connecting NE Maryland and Delaware. The consolidation of the Army's RDECOM at APG in MD is the major factor in creating this opportunity. The UD, as the closest Category 1 Research University, has a significant competitive advantage to capitalize on this opportunity. Already UD is engaged with RDECOM in collaborative research, graduate education and career development. Also UD is developing strong partner relationships with Cecil College, Harford Community College and SAIC, a major military prime contractor. These collaborations, combined with the development of UD's STAR Campus, provide the capability and capacity for significant economic development.

7. Agriculture

Agriculture in Delaware is an \$8 billion industry that has a significant and highly positive impact on the economic viability of the state and entire Delmarva region. Agriculture is Delaware's primary land use with farmland accounting for 41% of Delaware's land resources. Among all states in the USA, Delaware ranks first in average net farm income per farm and per acre. The state's proximity to major

urban centers such as New York, Philadelphia, Baltimore and Washington, DC has been a major factor in the long-term viability of Delaware agriculture and provides great opportunity for future investment in food production within the state. The growing interest in locally produced foods has provided Delaware farmers with even greater economic opportunities for success in local and regional markets.

Poultry production and processing dominates the agriculture landscape in Delaware representing approximately 74% of the market value of agriculture. In addition, Delaware's cropland is largely used for production of corn and soybeans, which support the poultry industry. Despite poultry's dominance, Delaware has significant vegetable and dairy product production, and expansion of the green industry is expected to continue. The equine industry is significant.

Agriculture in Delaware is practiced on a fragile landscape; the state is situated on a peninsula between the Chesapeake Bay and the Atlantic Ocean. Ensuring the compatibility of agriculture and environmental stewardship has long been a major priority for Delaware's agricultural industry. Strong partnerships exist between farmers, state and federal advisory agencies, environmental groups, and others that provide support to agriculture's efforts to produce food efficiently and safely, with minimal impact on water and air quality. Indeed, the state is viewed as a national model for how agriculture could be conducted in a world with an increasingly fragile environment, limited resources, and escalating human nutritional needs. This allows for rapid and efficient responses to any new challenges, such as the growing concerns associated with climate change effects on crop and animal production systems. For example, Delaware is a national leader in the adoption and management of irrigation for grain and vegetable crop production, essential to ensure food production during the frequent droughts that impact the state.

In addition to environmental concerns, Delaware agriculture is impacted by farm profitability, changing land uses and values, deforestation, evolving population demographics, government regulation, globalization and foreign trade policy, intergenerational issues, labor issues, and views of agriculture held by the general public as well as key decision-makers, and overall economic risks.

Strengths and Competitive Position

The Delaware Department of Agriculture conducts innovative programs such as Farm Land Preservation, the Delaware Rural Irrigation Program and the Young Farmer's Program, all designed to ensure the land and human resource, i.e., farms and farmers, for the future. The department also houses science-based regulatory, marketing and advocacy functions on behalf of Delaware agriculture. The University of Delaware's College of Agriculture and Natural Resources is one of seven colleges at the University and is committed to education, research, and outreach to address a wide variety of issues related to agriculture and natural resources. The College of Agriculture and Related Sciences at Delaware State University hosts two academic departments, as well as Agricultural Extension

also committed to teaching, research, and extension activities. Faculty at UD and DSU have built strong research teams with other leading universities in the US and other countries, to conduct fundamental research, develop efficient applied agricultural management practices, and support outstanding outreach programs in agriculture and natural resources.

In addition to the College of Agriculture and Natural Resources at the University of Delaware and the College of Agriculture and Related Sciences at Delaware State University, Delaware's investments in higher education related to agriculture include the establishment and support of the Delaware Biotechnology Institute (DBI), Delaware Environmental Institute (DENIN) and the new Interdisciplinary Science and Engineering (ISE) Laboratory all located at the University of Delaware and the Center for Integrated Biological and Environmental Research (CIBER) located at DSU.

In addition, investments at the University of Delaware Science Technology and Advanced Research (STAR) campus should benefit agriculture, especially at the interface of agriculture with human health.

Action Underway

Ensure that facilities for delivering critical services to agriculture are state-of-the-art. To meet the needs of poultry diagnostics and surveillance on the Delmarva Peninsula, the University of Delaware's Lasher Laboratory, located at the Elbert N. and Ann V. Carvel Research and Education Center in Georgetown, is completing a \$4 million renovation project funded by the State of Delaware through the Delaware Department of Agriculture. Since 2011, the Lasher Laboratory has received a \$500,000 in line item support for operations through the State and the Delaware Department of Agriculture. This laboratory is part of the National Animal Health Laboratory Network (NAHLN), and it is critical that it be poised to conduct day-to-day activities for support of the poultry industry as well as be ready to respond to disease emergencies that may arise at any time. Modernization of UD's Worrilow, Hall, now more than 30 years old, which houses advanced research laboratories in animal, plant, and soil sciences is another critical need. Opportunities for an agricultural presence at the UD STAR campus, particularly through broader collaborations with the UD College of Health Sciences, are now being investigated and should be expanded further.

In order to advance the investments for state-of-the-art agricultural research and development at DSU, the Baker Agricultural Building which houses research laboratories and classrooms for teaching, and associated research greenhouses are in urgent need of renovation in order to meet 21st century cutting-edge research capabilities.

Apply unparalleled scientific advances for the benefit of agriculture. The best available science needs to be applied to the following areas: poultry production; agronomic, vegetable, and horticultural crop production; nutrient management; livestock husbandry; soil, water and air quality, particularly in light of growing

worldwide concerns about climate change; environmental fate and remediation of nutrients, organics, and metals; biodiversity and ecosystem balance; land use and community development; food safety and food-borne illness; and human and animal nutrition.

The use of cross-disciplinary and collaborative approaches and the appreciation of both team-driven and individual investigator-initiated research are essential

Strengthen collaborations with diverse partners both local and beyond our borders. Our many existing partnerships (Delaware Department of Agriculture [DDA], Delaware Department of Natural Resources and Environmental Control [DNREC], Delaware Geological Survey, Longwood Gardens, Delmarva Poultry Industries, Inc. [DPI]; DuPont, many national research laboratories and first-rate universities, to name a few) are important to nurture, and we must continue to seek additional allies and collaborators to advance our priorities.

Nourish teaching and outreach activities. The link between academic research and the public is especially strong in agriculture and natural resources, led by the Cooperative Extension network. Faculty, research and extension professionals need to be better linked to production agriculture.. Faculty, research and extension professionals need to be better linked to production agriculture.