

# Indiana's Defense-Related Technology Assets and the Alignment of Higher Education's Research and Talent Generation Capacities

*Creating a High Value Environment for Growing  
Indiana's Defense Installations*



Final Report

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## List of Acronyms and Short Forms

AFR	Air Force Research Laboratory
AI	artificial intelligence
ARB	Air Reserve Base
ASOS	Air Support Operations Squadron
BRAC	Base Realignment and Closure
BWAC	Broadband Wireless Access and Applications Center
CAAA	Crane Army Ammunition Activity
CACR	Center for Applied Cybersecurity Research
CACTF	Combined Arms Collective Training Facility
CEDS	Center for Electronic Defense Systems
CIP	Classification of Instructional Programs
CISA	Center for Integrated Systems in Aerospace
CREST	Center for Research in Extreme Scale Technologies
CRI	Computer Research Institute
CSST	Center for Sensing Science and Technology
DARPA	Defense Advanced Research Projects Agency
DFAS	Defense Finance and Accounting Services
DGS	Distributive Ground Station
DoD	Department of Defense
DSC	Digital Science Center
EW	electronic warfare
ICC	Innovation & Collaboration Center
ICDS	Indiana Center for Database Systems
IDCAST	Institute for the Development and Commercialization of Advanced Sensor Technology
IGERT	Integrative Graduate Education and Research Traineeship
IODD	Indiana Office of Defense Development
ISEA	In-Service Engineering Agent
IT	information technology
IU	Indiana University
LEAST	Low Energy Systems Technology
MEMS	micro-electrical-mechanical-systems
MUTC	Muscatatuck Urban Training Center
NAVSEA	Naval Sea Systems
NCES	National Center of Educational Statistics

NCN	Network for Computational Nanotechnology
Ndnano	Notre Dame's Center for Nano Science and Technology
NSA	Naval Support Activity
NSF	National Science Foundation
NSF-ATE	National Science Foundation Advanced Technical Education
NSWC	Naval Surface Warfare Center
OPM	Office of Personnel Management
PIA	Partnership Intermediary Agreement
PRISM	Prediction of Reliability, Integrity and Survivability of Microsystems
PURVAC	Purdue Regional Visualization and Analytics Center
R&D	research and development
RCAC	Rosen Center for Advanced Computing
RF	radio frequency
STEM	science, technology, engineering and math
TPP	Technology Partnership Practice
UAH	University of Alabama
UAS	unmanned aerial systems
UAV	unmanned aerial vehicle
WBI	Wright Brothers Institute
WOMBAt	wideband optically multiplexed beamforming architecture

## Section 1. Introduction and Key Findings

At a time when Indiana is hard at work to accelerate the economic recovery taking place and generate rising incomes, it is essential to focus on those economic assets found across the state that can contribute to the state's economic progress. One significant economic asset that deserves close consideration is the direct defense-related activities taking place in the state. More than 10,000 Hoosiers are employed across Department of Defense (DoD) installations and facilities located in Indiana, including major installations found in the communities of Crane, Indianapolis, Butlerville, Edinburgh, Fort Wayne, Peru and Terre Haute.

These DoD jobs stand out in offering high quality jobs, paying an average of just over to \$70,000 compared to the state average private sector industry salary of just \$40,000. Most striking is that the Department of Defense activities in Indiana grew during the recession and by 2013 stood 13.7% higher than in 2007, representing a gain of 1,258. By comparison, total employment in Indiana was still 1.9% below its pre-recession 2007 level as of 2013.

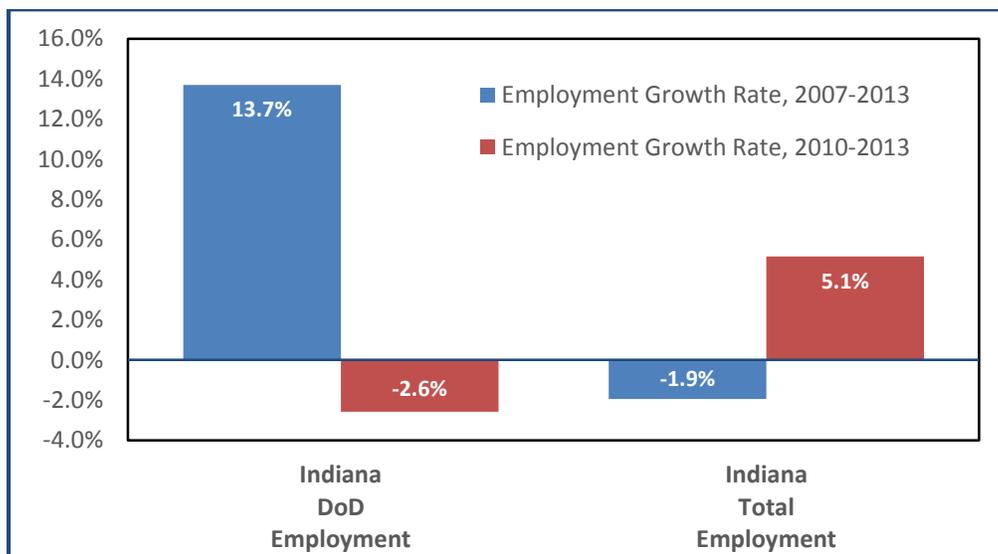


Figure 1. Growth in employment from 2007 to 2013: Department of Defense (DoD) employment compared to total employment in Indiana.

Source: DoD Employment from the U.S. Office of Personnel Management, Total Indiana employment from U.S. Bureau of Labor Statistics; Battelle calculations.

**A key question going forward is how to sustain and build upon Indiana's growth in DoD activities.**

In recent years DoD activities have been constrained due to federal spending caps on DoD's budget that began in 2011. Indiana has felt these financial constraints with the state's total DoD employment declining slightly from a high of 11,074 in 2011 to 10,395 in 2014. Looking to the future, the DoD budget is expected to grow again now that the economy has recovered and federal spending is picking up. The President's proposed 2016 budget for DoD calls for a 4.5 percent increase over the 2015 enacted level and exceeds spending caps from the prior year by \$38 billion. At the same time, there may be new

challenges as Congressional discussions are growing on having a new Base Realignment and Closure (BRAC) round beginning in 2017. This translates into an uncertain environment going forward, where Indiana's defense installations will need to make the case that they are good investments for growth and, possibly, retention.

### **Role of Technology and Talent Efforts to Sustain and Enhance Defense Installations within States**

Best practices from across the U.S. suggest that sustaining state-specific DoD activities requires ensuring a high value-added, local environment for its defense installations. To this end, Indiana has taken one of the most important steps by establishing the Indiana Office of Defense Development (IODD) in 2013 in recognition of the importance of Department of Defense employment, its defense-related installations, and its defense contractor base. IODD provides a focused effort on growing the defense sector business in Indiana and creating jobs for Hoosiers.

Given that the U.S. military is among the most technology-sophisticated organizations in our nation, IODD recognizes the importance of assessing the specific technology development, deployment, and talent requirements of its leading military installations to determine Indiana's ability to assist in advancing military technology capabilities, which in turn could lead to added facilities, activities, and ultimately employment as DoD makes strategic investments across the nation.

Similar to industry, the U.S. military has a competitive advantage through the use of technology. As the Association of American Universities explains: "DOD relies on technological innovation as a force multiplier, and cutting-edge advances have helped make our military the best-equipped and most effective in the world. Addressing complex military challenges – such as improvised explosive devices, information warfare, and weapons of mass destruction – requires new technologies. The new knowledge needed to develop such technologies depends on sustained investments in basic research performed at U.S. universities. Past DOD investments in university basic research have led to such innovations as lasers, radar, fiber optics, infrared technologies, stealth technology, and advanced composite materials."<sup>1</sup>

Much of that advanced technology capability involves the ability to link key state and regional resources involving talent, science and innovation to serve the continuing high performance and enhancement of missions at military installations. Of particular importance is how a state's post-secondary institutions and its broader industry drivers are aligned to meeting the needs for talent and technology know-how required for advancing the nation's military missions.

In recent years, ensuring that local military installations have access to science, technology, engineering and math (STEM) talent pipeline has become a growing concern. The DoD's 2010–2014 STEM Education and Outreach Strategic Plan notes a variety of challenges facing DoD in its access to technology-skilled workforce, including<sup>2</sup>:

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<sup>1</sup> <http://www.aau.edu/WorkArea/DownloadAsset.aspx?id=14378>.

<sup>2</sup> Department of Defense, STEM Education and Outreach Strategic Plan: 2010-2014, December 2009, page 3

- The average age of federal scientists and engineers continues to rise. Workers age 45 and older constituted 57.8 percent of all federal scientists and engineering in 2005. A significant portion of these employees, particularly those in DoD science and technology laboratories, will likely leave by 2020 through retirement or attrition.
- The current DoD workforce also lacks diversity. The proportion of women scientists and engineers in DoD laboratories has not kept pace with the proportion in the U.S. workforce as a whole.
- Competition for world-class talent is increasing. The difference in starting salaries between the private and public sectors is a systemic challenge for DoD. Plus, DoD faces the additional hiring hurdle of security clearance requirements that often exclude highly talented individuals who are not U.S. citizens.

So, along with other efforts in support of its military installations, it is critical that Indiana ensure a high value local environment that can link key knowledge assets involving talent, science and innovation resources to serve the continuing high performance and enhancement of its leading military installations.

### **Assessing the Alignment of Indiana's Higher Education Institutions to the Technology and Talent Needs of the State's Defense Installations**

Understanding the importance that access to technology and talent will play in Indiana's ability to not only grow but also retain the military installations in the state, IODD decided to undertake an independent, fact-based assessment of the alignment of Indiana's higher education institutions to the technology development, deployment, and talent requirements of Indiana's core military installations. IODD retained the services of the Battelle Technology Partnership Practice (TPP) to undertake the assessment.

Battelle is the world's largest independent, non-profit, research and development organization, with extensive knowledge of DoD. Battelle created the Technology Partnership Practice in 1991 to focus Battelle's broad experience and capabilities to better serve state and local organizations, universities, non-profit technology organizations, and others in the design, implementation, and assessment of economic and technology development programs. Today, TPP is one of the nation's premier technology-based economic development consulting organizations bringing an extensive and proven track record in developing overall science, technology, and innovation strategies for states, as well as more focused talent/workforce strategies. Battelle TPP also has an extensive track record of working in Indiana and brings a strong familiarity and knowledge of Indiana's diverse set of universities and industry drivers.

The key components for this fact-based, independent assessment involved:

1. Identifying what the key technology focus areas are of Indiana's leading defense installations.
2. Assessing how Indiana universities' research activities align with the state's defense installations technology focus areas .
3. Examining the demand for workers across all defense installations and assessing the specific workforce needs and then analyzing if Indiana's talent generation is in alignment with demand.

### **Key Findings**

Based on the interviews with key leadership at Indiana's leading defense installations and publically-available information regarding the mission, activities, capabilities, and assets of these defense

installations, six technology focus areas associated with technology development, deployment and talent needs across the five leading defense installations were identified. These six technology focus areas included:

- Electro-Optics, Sensors and Surveillance
- Advanced Electronics
- Chemistry Materials
- Information Technology/Computer Science
- Warfighter Technologies
- Unmanned Aerial Systems.

The alignment of higher education research and development activities to these core technology areas presents a paradox:

- Indiana's academic research, as represented by funding, papers and research centers, offers a significant and growing level of research in fields aligned with the technology needs of Indiana's leading defense installations.
- Yet, DoD support for academic R&D in Indiana, while increasing since 2008, accounts for a smaller share of total funding across all aligned research fields and has not kept pace with overall DoD support to universities.
- The implication is that more focused efforts are needed in Indiana to aggressively pursue DoD funding based on the growing strengths of Indiana's universities in key research fields aligned to the targeted technology/talent focus areas are required.

In the alignment of talent generation from higher education in Indiana, the findings were more straightforward:

- Indiana's higher education community is particularly well-aligned in the growing areas of DoD-related employment opportunities for bachelor and graduate level degrees. The state offers access to top ranked programs in key engineering, scientific, and computer fields, with strong focus on the state's aerospace, electronics, and computing talent needs.
- One opportunity for improvement identified was for more Associate degree level technical skill areas involving *electrical, electronics, and communications technicians*, and *aerospace, aircraft and avionics technicians*. Many of Indiana's leading defense installations identified this as a specific workforce need. Overall, outside of computer sciences, the level of Associate's degrees awarded in the targeted defense-related degree areas has declined, especially in key technical and technician programs.

Thus, there are opportunities for pursuing new collaborative efforts to better connect the existing Indiana university research strengths to DoD opportunities, and to pursue more collaborative program development at the Associate Degree level for specific technical fields.

## Section 2. Setting the Context – Assessing the Technology and STEM Talent Requirements of Indiana's Five Core Defense Installations

Indiana is home to five leading military installations:

- Camp Atterbury Joint Maneuver Training Center and Muscatatuck Urban Training Center
- Grissom Air Reserve Base
- Hulman Field
- The Fort Wayne International Airport
- The Naval Surface Warfare Center and Army Ammunition Activity at the Crane Military Base.

Table 1 below provides summary information on the location, employment, and budget of these leading military installations in Indiana.

**Table 1. Overview of five Indiana key defense installations.**

Installation	Location	Employment*	Budget
Camp Atterbury Joint Maneuver Training Center and Muscatatuck Urban Training Center	Edinburgh Butlerville	1,000	\$300 million
The Fort Wayne International Airport	Fort Wayne	1,000–1,100	\$65 million
Grissom Air Reserve Base	Peru	2,000–2,300	\$100 million
Hulman Field	Terre Haute	850	\$25 million+
NSA Crane (Naval Surface Warfare Center and Army Ammunition Activity)	Crane	4,600	\$2 billion

\* Full Time and Reserves.

Source: Battelle Interviews and Review of Websites.

To identify the critical technology development, deployment, and talent requirements of the five core installations, information regarding mission, activities, capabilities, and assets of these bases was reviewed and analyzed. In addition, Battelle conducted interviews with the leadership at the five military installations to collect more detailed information regarding their specific technology and talent requirements, as well as their ongoing collaborations and connections with Indiana industry and universities.<sup>3</sup> To further assess DoD-related talent/workforce needs in Indiana, Battelle also conducted an additional analysis of overall federal defense related employment and hiring in Indiana based on the U.S. Office of Personnel Management (OPM) FedScope Federal Human Resources Database for the entire

<sup>3</sup> A list of persons interviewed is included as Appendix A. and the Interview Guide is included as Appendix B. to this report.

Department of Defense, Department of the Air Force, Department of the Army, and Department of the Navy.<sup>4</sup>

Brief profiles are provided below of the leading DoD military installations, followed by an integrated technology framework of the key defense-related technologies being developed through research and development activities and/or deployed in the fulfillment of the mission.

## Profiles of Indiana's Leading DoD Installations

The profiles below provide a brief history, current mission, and insights on technology development and deployment activities associated with each of the five leading DoD installations in Indiana:

**Camp Atterbury – Muscatatuck** began operations in 1942 as a training facility during WWII. The camp was discontinued as a Department of the Army facility in 1969. The Military Department of Indiana assumed control at that time, and from the 1970s through the 1990s the primary mission of Camp Atterbury-Muscatatuck was to support the Indiana National Guard and its various missions, including providing support with conflicts in Vietnam, Desert Shield, and Desert Storm. Camp Atterbury-Muscatatuck now functions as an armed forces reserve training area operated by the Indiana National Guard. The base supports active duty and reserve component training, as well as other local, state, and federal training.

Located close to Camp Atterbury-Muscatatuck and developed in conjunction with the State of Indiana, the **Muscatatuck Urban Training Center (MUTC)** is a large urban training site, leveraging existing masonry buildings, supporting Camp Atterbury urban training requirements, while also providing a unique training venue for other Army units, DoD exercises, and Federal agencies. The 1,000 acre site was turned over to the Indiana National Guard in July of 2005, and has since been evolving into a full-immersion contemporary urban training environment. The MUTC includes:

- A 180-acre reservoir
- A flooded community
- More than 180 structures including 68 major buildings covering 850,000 square feet of floor space
- An extensive searchable/maneuverable and instrumented utility tunnel system
- More than 9 miles of roads and streets
- Electromagnetic environment
- The Combined Arms Collective Training Facility (CACTF)
- An engineered rubble pile.

The strategic mission of Atterbury-Muscatatuck is to support the training of DoD and National Guard personnel for foreign deployment. Because of the reduction of military activities in Afghanistan and Iraq and subsequent reduction in the need for deployment-related training, the employment of the base has declined from over 2,500 during the height of the Afghanistan and Iraq conflicts to approximately 1,000

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<sup>4</sup> It is important to note that the OPM FedScope analysis was conducted for all, DOD, Air Force, Army, and Navy installations in Indiana, not just the five bases that are the focus of this analysis. This was necessary because this employment data is available by the various DOD and service commands, not by installation. Thus, the OPM data analysis is broader and includes all defense-related federal employment in Indiana.

today. According to the Base Commander, "Our old mission was training; our new mission is testing and evaluation along with training." The current goal of the installation is to integrate cyber, communications, and unmanned systems technology and training into its core military and Special Forces training mission. The base is also seeking to diversify its base of training customers to include the Department of State, the Department of Homeland Security, and civilian clients, as well as its core DoD and special operations clients. For example, in 2013, the facility hosted Vibrant Response, the largest annual homeland security exercise in the country with 8,000 military and civilian participants from 27 different states.

While Camp Atterbury and Muscatatuck are not significant generators of defense technologies, they offer significant capacity for technology training, testing, and evaluation, especially in the areas of **cybersecurity**, **communications**, and **unmanned aerial systems**. In addition to its mission to serve as a mobilization and training center, Camp Atterbury and Muscatatuck offers a full Electro-Magnetic Environment, managed by Crane NSWC, that offers a full range of telecommunications and data communications systems. The installation has also been granted clearance for specific ground-based electronic attack. Thus, the installation has focused on both training and testing operations related to sensor, communications, and cybersecurity technologies. Atterbury-Muscatatuck is also a central element of Indiana's efforts to develop, test, and deploy unmanned aerial systems, and is a major part of Indiana's significant assets that are being deployed to support unmanned aerial systems technology development, testing, and training. Indiana's unmanned aerial systems assets and resources include:

- 280 square miles of Restricted Airspace
- 1,300 square miles of Military Operating Airspace
- Over 100,000 acres of real estate under Restricted Airspace
- A Joint National Training Center with Complex Urban Training
- DoD and Non-DoD partners vested in UAV technologies
- A 4,200 foot runway under Restricted Airspace
- A National Test Network for communications support that is being deployed to support the development, training, and testing needs related to unmanned aerial systems development.

As a core component of this capacity, MUTC is designated as a Joint National Training Center and offers a key, national-level capability for testing, evaluating, and training environment for both soldier and civilian users of unmanned systems. Considered the largest, fully-functional brick and mortar urban training environment in the U.S., Muscatatuck offers the only site in the nation where unmanned systems, including but not limited to UAVs, can fly in restricted airspace and collect data from an urban environment. Finally, as part of its core training mission, Atterbury-Muscatatuck also provides world class facilities (capabilities and capacity) to Special Operations Forces, as the best value solution for live, virtual, and constructive training, testing, and evaluation in order to meet their operational and strategic requirements for the contemporary operating environment.

In expanding its training mission to include defense technology testing and evaluation, Atterbury-Muscatatuck works closely with NSWC Crane in Indiana, the Air Force Institute of Technology and the Air Force Research Lab at Wright Patterson Air Force Base in Ohio, as well as Naval Sea Systems (NAVSEA) Dahlgren and Defense Advanced Research Projects Agency (DARPA). Atterbury-Muscatatuck has substantial cooperative efforts underway with Indiana colleges and universities including Indiana

University in cybersecurity, Indiana State University in unmanned aerial systems, and Indiana University, Purdue University, and Vincennes University on its training operations. Employment at Atterbury-Muscatatuck has stabilized after recent reductions with the major talent need being in the area of information technology with a significant focus on cybersecurity.

**Grissom Air Reserve Base (ARB)** is one of only five standalone Air Force Reserve Command bases in the nation. It began operations on July 1, 1942 when it was opened by the U.S. Navy as Bunker Hill Naval Air Station. The base was renamed in 1968. With total employment of 2,300 civilian, active duty and reserve personnel and a budget of approximately \$100 million, Grissom ARB plays an important role in the regional and state economy. It is the largest employer in Miami County and the third largest in North Central Indiana. Its annual economic impact exceeds \$128 million per year.<sup>5</sup>

Grissom ARB is the home of the 434th Air Refueling Wing, one of the key aerial refueling units in the Air Force Reserve Command. From the base, the wing and its personnel travel around the world in support of various Air Force operations and contingencies. The wing is equipped with 16 KC-135R Stratotanker aircraft.

The mission of the 434th Air Refueling Wing is to develop and maintain the operational capability of its units and train reservists for worldwide duty. Training consists of flight operations, deployments, and weekend training. It also has responsibility to generate aircraft and crews in support of the Air Mobility Command. While the Air Force has the largest contingent of personnel at Grissom, it is also home to organizations from other branches of America's armed forces. The Army Reserve has had a presence at Grissom since the 1970s, and a Marine Corps Reserve unit relocated to the base in 2001.

With this focus on providing tactical and strategic refueling to support national defense, Grissom has only limited direct involvement in the generation of Air Force and aviation technologies. As a result, the ARB has only limited involvement in Indiana research and development activities. Grissom ARB is, however, actively involved in the utilization and deployment of existing Air Force and aerospace technologies. Local procurement and contractor activity is focused on base support functions and procurement to support its core refueling mission. The ARB also recruits skilled workers from the Indiana education system. Its workforce needs include pilots and aircraft/avionics technicians to support its core mission. The ARB also has a need to recruit flight surgeons and medical personnel.

**Fort Wayne International Airport** is home to the 122nd Fighter Wing, which flies the A-10 Thunderbolt II out of the Fort Wayne Air National Guard Base. The Fort Wayne International Airport is adjacent to the base and is also known by its original name, Baer Field. Approximately 1,100 total staff work at the 122nd, ranging from finance and medical personnel to the many A-10 service personnel. The Army's 338th Quarter Master Field Service Company also resides on base. The base has a total operating budget of approximately \$65 million.

The core mission of the Fort Wayne International Airport/122<sup>nd</sup> Fighter Wing is to support the combat readiness of its A-10 aircraft and crews. With this focus on providing agile combat support, the Fort

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<sup>5</sup> <http://www.grissom.afrc.af.mil/news/story.asp?id=123437484> and <http://www.grissom.afrc.af.mil/library/factsheets/factsheet.asp?id=2205>

Wayne International Airport/122nd Fighter Wing has only limited direct involvement in the generation of Air Force and aviation technologies and mostly deploys existing military aerospace technologies. As a result, the Fort Wayne International Airport/122nd Fighter Wing has only limited involvement in Indiana research and development activities. Local procurement and contractor activity is focused on base support functions and procurement to support its core air defense mission. Similar to Grissom ARB, the 122<sup>nd</sup> Fighter Wing has specific technology workforce needs for pilots and aircraft/avionics technicians to support its core mission, as well as medical personnel to support base operations.

**Hulman Field** was developed as an airport in 1943. A local Air National Guard Base was established at the airport in 1954, and the 113th Tactical Fighter Squadron, which is a part of the 181st Tactical Fighter Group, was stationed at the airport. Today, The Terre Haute International Airport-Hulman Field is the home of the 181st Intelligence Wing. The unit's mission was changed with the 2005 Base Realignment and Closure Commission, and today is tasked with two Air Force missions: a Distributive Ground Station (DGS) and an Air Support Operations Squadron (ASOS). Both of these missions places the 181st in the deployment and utilization of unmanned aerial vehicle (UAV), sensing and communications technology. The DGS is an intelligence-based mission, monitoring near real-time video feed from Predators, Global Hawks, and other unmanned aerial vehicles hovering the skies over any military area of operation. The ASOS mission is to advise the ground commanders on the best way to utilize U.S. and NATO assets for close air support. The Wing's mission support group supports the operation of the overall command. In 2008, the 181st Fighter Wing was re-designated as the 181st Intelligence Wing. The total employment of all three operations is approximately 800 personnel and the total base budget is over \$25 million. All of the intelligence staff have the highest level of security clearance. The base also hosts the Indiana National Guard 81st Troop Command, which is focused on disaster readiness.

The Hulman Field the 181st Intelligence Wing deploys a wide range of technologies related to the intelligence mission of the base, including communications, telecommunications, information technology (IT), and unmanned aerial systems (UAS). Two specific areas of significant and growing technology deployment and workforce focus areas were noted in Battelle's interviews. One is in the area of cybersecurity used to protect intelligence/communications assets. Another key technology and workforce area is in sensing and surveillance technology to collect, analyze and disseminate intelligence information involving signaling, imaging, and sensor platform deployment.

Currently, Hulman Field is well-positioned in meeting its workforce needs, being fully staffed with a high workforce retention level. There are also active partnerships and contractors involved in supporting the technology deployment and talent needs for Hulman Field. The installation has formal relationships with ROTC programs across the state and an informal working relationship with Indiana State University in unmanned aerial systems. Plus, the base utilizes major DoD contractors, including Lockheed Martin, SAIC, and Raytheon, to maintain its intelligence/communications technology.

**Naval Support Activity Crane (NSA Crane)** is the third largest U.S. Naval installation in the world. Originally established in 1941 under the Bureau of Ordnance as the Naval Ammunition Depot for production, testing, and storage of ordnance, Crane has evolved from its ordnance roots and is now recognized worldwide as a modern and sophisticated leader in diverse and highly technical product lines serving both the U.S. Departments of the Navy and Army.

NSA Crane, as both a federal “national laboratory” and a principal weapons depot, has historically been in the forefront of U.S. weapons development. NSA Crane and its two core commands work with both DoD and its civilian contractors to support the design, development, testing, and production of advanced military products, equipment, and technologies. Through its partnering with the contractor community, NSA Crane has supported the development of a national security/defense business cluster in Southwest Central Indiana that together employs nearly 5,600 military, civilian and contractor jobs and generated a business base of more than \$2 billion in FY 2013.<sup>6</sup>

Housed at NSA Crane are two primary divisions that are described briefly below.

**The Naval Surface Warfare Center (NSWC) Crane** is a shore command of the U.S. Navy. NSWC Crane is one of ten warfare center divisions across the U.S. within the Naval Sea Systems (NAVSEA) Command. The mission of NSWC Crane is to provide acquisition engineering, in-service engineering, and technical support for sensors, electronics, electronic warfare, and special warfare weapons. NSWC Crane also works to apply component and system-level product and industrial engineering to surface sensors, strategic systems, special warfare devices, and electronic warfare/information operations systems. NSWC not only directly employs over 3,000 government workers, it also involves more than 1,500 contractors, making it one of Indiana’s largest employers.

The focus for NSWC Crane is to provide the technical, innovative, leading-edge engineering solutions for many of the systems that protect and enable critical military missions. These missions include:

- Electronic Warfare/Information Operations Mission at NSWC Crane that provides the technology solutions to enable the U.S. military to control the electromagnetic spectrum critical to modern command and control systems used on the battle field. NSWC’s capabilities develop the solutions to destroy an adversary’s combat capability, gather intelligence, and enable friendly use of the electromagnetic spectrum.
- Strategic Missions at NSWC Crane provides the Navy’s preeminent facility for the design and testing of radiation hardened electronics, including every subsystem of the Navy’s Trident submarines’ strategic weapons system.
- Special Missions at NSWC Crane is a major supplier of weapons, sensors, and equipment used by U.S. Special Forces.

NSWC Crane stands as one of Indiana’s largest technology employers, with more than 3,000 employees of which approximately two thirds are scientists, engineers and technicians. NSWC Crane requires a wide range of specialized scientific and engineering expertise spanning electronics engineering, mechanical engineering, computer science/engineering, chemical engineering, and physicists, among other fields. A growing area of skill need is in systems engineering involving modeling and simulation of complex systems. In addition, NSWC draws on other skilled talent including electronic and engineering technicians, business and accounting and logistical support. The aging of NSWC Crane’s workforce is of particular concern with the average age of its workforce now exceeding 45 years old, and approximately 30% of its scientific and engineering workforce will be eligible for retirement in the next 3–5 years.

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<sup>6</sup> See the Battelle report a Strategic Plan for Economic and Community Prosperity in Southwest Central Indiana for a more complete description of NSA Crane and its related security/defense business cluster.

**The Crane Army Ammunition Activity (CAAA)** was established October 1, 1977 with a mission to receive, store, ship, produce, renovate, and demilitarize conventional ammunition, missiles, and related components to meet contingency requirements in support of the warfighter. CAAA offers a wide variety of products and services to both the government and private industry in the production and testing of ordnance. It draws upon logistics and other enterprise resource management IT capabilities in advancing its mission. Most of CAAA's 600 to 800 employee workforce is similar to what would be found among industrial and manufacturing employers in Indiana, with a growing emphasis on technical skills at a post-HS certificate or Associate Degree level. Among higher skilled technology talent requirements, CAAA has needs for workers in logistics management and computer science fields to operate its enterprise resource planning system. It also has an aging workforce with its average age standing above 47 years old.

### **Integrated Technology Framework for Indiana's Leading DoD Installations**

Based on the interviews with the leadership at the five leading defense installations as well as available information regarding mission, activities, capabilities, and assets of these bases, Battelle identified the technology development, deployment and talent requirements of Indiana's five core military installations. This identification of technology needs also benefitted from Battelle's prior analysis of NSWC Crane and CAAA conducted as part of the comprehensive economic development strategy for Southwest Center Indiana Region. Six broad areas of technology focus with associated technology development, deployment and talent requirements across the five leading Indiana defense installations stand out, including:

- Electro-Optics, Sensors and Surveillance;
- Advanced Electronics;
- Chemistry Materials;
- Information Technology/Computer Science;
- Warfighter Technologies; and
- Aerospace and Unmanned Aerial Systems Technologies.

Many of these core technology focus areas are shared across the leading defense installations in Indiana. Only two of the core technology focus areas are not found at multiple defense installations – chemistry materials and advanced electronics – which are more technology development areas associated only with NSWC Crane. Table 2 below provides a mapping of the technology focus areas associated with technology development, deployment and talent to the leading defense installations in Indiana.

**Table 2. Crosswalk of identified core technology focus areas to Indiana’s leading defense installations.**

Installation	ElectroOptics, Sensors and Surveillance	Advanced Electronics	Chemistry Materials	Information Technology/Computer Science	Warfighter Technologies	Aerospace and Unmanned Aerial Systems Technologies
Camp Atterbury/Muscatatuck Urban Training Center	X			X	X	
Grissom Air Reserve Base						X
Hulman Field	X			X		X
The Fort Wayne International Airport						X
The NSW Center and Army Ammunition Activity at the Crane Military Base	X	X	X	X	X	

A description of the six technology focus areas including specific range of capabilities, insights from the interviews conducted, and broad areas of talent/workforce requirements is presented below.

### Electro-Optics, Sensors and Surveillance

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#### ***Specific Technology Capabilities***

- Intelligent Sensors and Sensor Networks (e.g., Wireless, Very Low Power, Low Cost, Very Large Format)
- Radar Systems
- Remote Sensing
- Optic/Electro-Optic/Infrared Sensors, Detectors, and Materials
- Advanced Laser Technologies and Applications – Including Material Processing
- Secure/Trusted Electronics
- Security/Biometric Technologies

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#### ***Insights from Interviews***

- NSWC Crane has historic strengths and capacities in radar systems and threat detection (e.g., AEGIS system).
- NSWC Crane has DoD’s largest concentration of electronic warfare (EW) expertise (e.g., stand-off jammers; receivers; capabilities to design and develop small EW devices; anti access/area denial jamming devices). This expertise covers the gamut of the radio frequency (RF) and electromagnetic spectrums. They are considered to be the RF/wireless experts for the Navy.

- Hulman Field-181st Intelligence Wing has considerable experience in the area of sensor technology, including the use of electronic technology to collect, analyze, and disseminate intelligence information. The command has experience in signaling, imaging, and platform deployment.

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### ***Broad Talent Requirements***

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- Computer/Engineering Technicians
- Computer Science
- Electrical Engineering
- Systems Engineering

### **Advanced Electronics**

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### ***Specific Technology Capabilities***

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- Energy, Power, and Interconnect Technology – including Energy Harvesting
- Radar/RF/Electromagnetic Spectrum Technologies
- Semiconductor Materials & Technologies
- Microelectronics Technologies
- Anti-Tamper Technologies
- Other Electronic Warfare Technologies

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### ***Insights from Interviews***

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- The development and testing of extremely high reliability electronics is a core part of NSW Crane, including having a long-term engagement of supporting the Trident Missile Program.

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### ***Broad Talent Requirements***

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- Computer/Engineering Technicians
- Computer Science
- Electrical Engineering
- Systems Engineering
- Physics

### **Chemistry Materials**

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### ***Specific Technology Capabilities***

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- Battery Chemistry/Design/Testing
- Radiation Hardened Electronics/Materials
- Lightweight materials and power sources
- Nanoscale Materials/Technologies
- Pyrotechnics

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***Insights from Interviews***

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- Involved in wide range of battery/energy system needs from supporting missile systems to manned/unmanned vehicles to warfighter combat systems. Focus is on battery chemistries to improve power/weight ratio. Includes state-of-the-art testing capacities for energy performance and battery safety.
- Materials capabilities in radiation hardening of electronics are essential for supporting nuclear missiles.
- Focus on energetic materials involved in pyrotechnics and countermeasures.

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***Broad Talent Requirements***

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- Chemical Engineering
- Chemistry
- Physics

## Information Technology/Computer Science

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***Specific Technology Capabilities***

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- Cybersecurity/Cyberwarfare Software/Tools
- Digital and Cognitive Signal Processing
- Video/Image Analytics and Processing – Advanced Image Processing/Recognition
- Computer/System Interface – Displays, Direct Human Interface, Novel Controls
- Modeling, Simulation, and Visualization Software/Technologies
- Computer Network Operations
- Logistics Management Software and Tools

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***Insights from Interviews***

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- NSW Crane is working on the intersection of communications technology and cyber security/warfare. Involving growing capacity in systems engineering.
- Camp Atterbury Joint Maneuver Training Center and Muscatatuck have substantial capabilities for testing cybersecurity and cyberwarfare technology and has established an ElectroMagnetic test area.

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***Broad Talent Requirements***

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- Computer Engineering Technology/Technician
- Computer Science and Information Technology (All)
- Computer, Communications, Electrical and Software Engineering

## Warfighter Technologies

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### ***Specific Technology Capabilities***

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- Human Performance Augmentation
- Weaponry, Armor, Camouflage
- Wearable Support Systems (e.g., displays, power, sensors, etc.)

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### ***Insights from Interviews***

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- NSWC Crane, through its Special Missions focus, is a center of excellence in developing the equipment used by U.S. Special Forces. Emphasis is placed on enabling more portable and lightweight expeditionary combat systems and addressing warfighter needs for irregular combat and counter-terrorism.

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### ***Broad Talent Requirements***

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- Materials Engineering
- Mechanical Engineering
- Computer, Electrical, Software and Systems Engineering

## Aerospace and Unmanned Aerial Systems Technologies

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### ***Specific Technology Capabilities***

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- Aviation Technologies
- Remote Sensing and Communications

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### ***Insights from Interviews***

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- NSWC Crane supports a wide array of sensor and communications systems involved with unmanned aerial systems.
- Camp Atterbury/Muscatatuck provides both testing and training capacity in the use of Unmanned Aerial Systems (UAS).
- Grissom ARB and the 122<sup>nd</sup> Fighter Wing at Fort Wayne International Airport are actively involved in the utilization and deployment of existing Air Force and aerospace technologies translating into talent needs for pilots and aircraft/avionics technicians.

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### ***Broad Talent Requirements***

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- Aerospace/Avionics Technicians
- Aeronautical Engineering
- Computer Engineering Technology/Technician

The next section examines in detail how Indiana higher education aligns to these technology focus areas of Indiana's leading defense installations. It will draw on a variety of ways to measure Indiana's university research activities to assess the extent of alignment with the technology focus areas.

## Section 3. Research Alignment of Indiana's University R&D Capabilities to the Technology Framework of Indiana's Five Core Military Installations

In order to assess the role of Indiana's higher education community as performers of research and development and generators of technology to support both national defense and the specific technology development and deployment needs of Indiana's five core military installations, Battelle analyzed trends in research and development activity, scholarly publications activity, and identified key academic research programs and centers in the targeted technology focus areas at Indiana colleges and universities. Based on the technology focus area profiles, Battelle conducted a mapping analysis to assess the extent of research and scholarly activities found across all Indiana colleges and universities in the targeted technology focus areas.

### Alignment of Research and Development Expenditures and Publications with Technology Focus Areas of Indiana's Leading Defense Installations

Research and development expenditures by field for all universities conducting research in the U.S. (nearly 800 in all) are maintained by the National Science Foundation. This university research and expenditures database offers measures on the level and trends in broad areas of research activity found at universities corresponding to departmental levels of activity at a university. Battelle identified a crosswalk of specific university research fields by the six technology focus areas as set out in Table 3.

**Table 3. Crosswalk of Identified Technology Focus Areas of Indiana DoD Installations and Academic Research Fields.**

Academic Research Fields	Electro-Optics, Sensors and Surveillance	Advanced Electronics	Chemistry Materials	Information Technology/Computer Science	Warfighter Technologies	Aerospace and Unmanned Aerial Systems
Aerospace Engineering						X
Chemical Engineering			X		X	
Electrical Engineering	X	X		X		X
Mechanical Engineering	X				X	X
Materials Engineering			X			
Other Engineering	X	X			X	X
Chemistry			X		X	
Physics	X	X	X			
Mathematical Sciences				X		
Computer Sciences	X	X		X		X

Source: Interviews and Battelle analysis.

An analysis of the level of R&D activities taking place at Indiana universities by research field as well as the extent of DoD funding to Indiana universities provides the following key findings:

**Indiana's universities have a substantial level of university research funding in the academic research fields aligned to the key technology focus areas found across Indiana's leading DoD installations, reaching \$413.4 million in 2013.** This includes over \$50 million annually in chemistry, electrical engineering, computer sciences, mechanical engineering, and physics. Indiana ranks quite high among the states in a number of these fields, with chemistry ranking 8<sup>th</sup>. and aeronautical engineering, chemical engineering, and computer sciences each ranking 9<sup>th</sup> (Table 4).

**Table 4. Indiana Funding Level and National Ranking in Academic Research Fields Aligned to Key Technology Focus Areas Found Across Indiana's Leading DoD Installations.**

Aligned Academic Research Field	2013 Expenditures (\$1,000s)	National Ranking
Aerospace Engineering	\$28,394	9 <sup>th</sup>
Chemical Engineering	\$28,949	9 <sup>th</sup>
Electrical Engineering	\$58,120	14 <sup>th</sup>
Mechanical Engineering	\$53,244	11 <sup>th</sup>
Materials Engineering	\$10,173	21 <sup>st</sup>
Other Engineering	\$46,898	13 <sup>th</sup>
Chemistry	\$61,634	8 <sup>th</sup>
Physics	\$53,161	12 <sup>th</sup>
Mathematical Sciences	\$15,041	15 <sup>th</sup>
Computer Sciences	\$57,755	9 <sup>th</sup>
Total, Aligned Academic Research Fields	\$413,369	11 <sup>th</sup>

Source: National Science Foundation Higher Education Research and Development Expenditures, 2013 and Battelle analysis.

**Indiana is generally growing more rapidly than the U.S. in the academic research fields aligned to the key technology focus areas found across Indiana's leading DoD installations.** From 2010 to 2013, Indiana's universities recorded strong growth in the specific nine academic research fields mapped to key technology focus areas found across Indiana's leading DoD installations. Overall Indiana's research funding grew by 31 percent in the academic research fields associated with the key technology focus areas found across Indiana's leading DoD installations, while these same fields grew by only 12 percent nationally. In five of the nine academic research fields, Indiana grew by more than 40 percent in just the four years from 2010 to 2013, including computer sciences, aerospace engineering, chemical engineering, mechanical engineering, and materials engineering. More limited growth was recorded in mathematics, chemistry, physics, and electrical engineering. More impressive is that in eight of the nine academic research fields, Indiana outpaced national growth, and for several by more than double the U.S. growth rate.

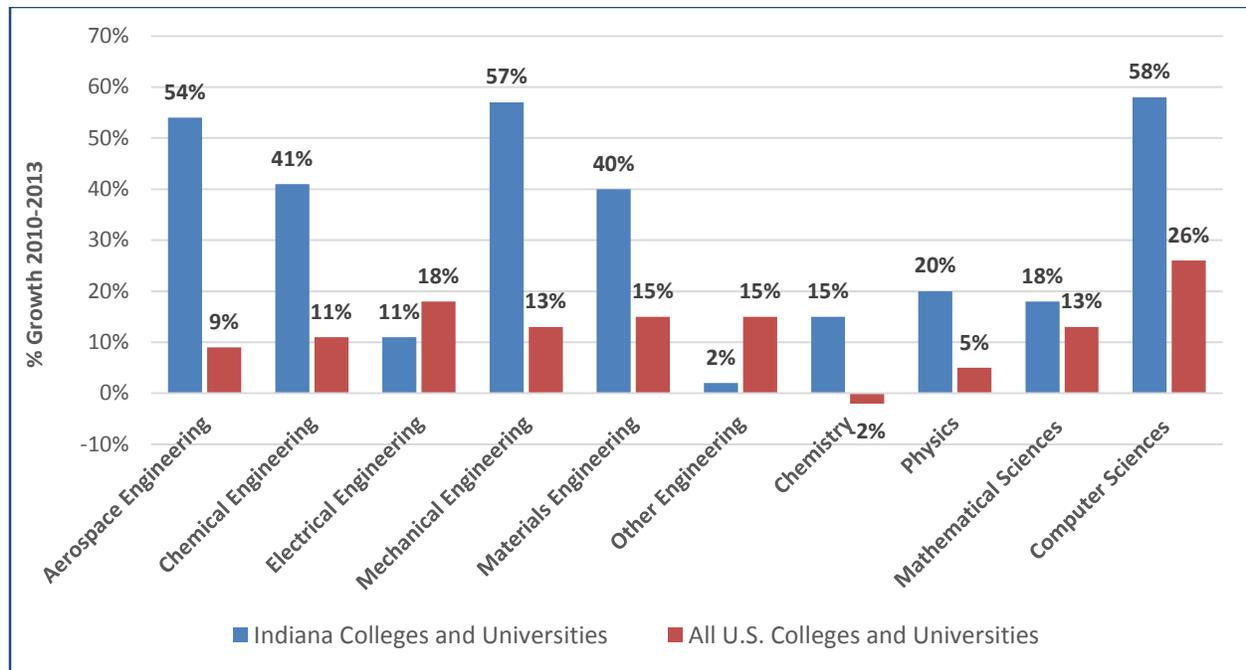


Figure 2. Growth from 2010 to 2013 in aligned academic research fields.

Source: National Science Foundation Higher Education Research and Development Expenditures, 2010 and 2013 and Battelle analysis.

**Scholarly activities of Indiana universities in peer-reviewed publications confirms in a more detailed level the strong alignment to the technology focus areas of Indiana’s leading defense installations.** In order to provide a more focused analysis of the six technology focus areas, data on the number of articles contained within peer-reviewed publications were analyzed from Thomson-Reuter’s Current Content Connect database, which tracks peer-reviewed publications across more than 120 disciplines and research areas. Using this database, Battelle was able to develop a measure of importance of key fields—Indiana’s share of U.S. publications in the disciplines that align with or support the six technology focus areas.

Across a number of disciplines, Indiana’s publication (primarily academic) strengths show potential for engagement and research activities supporting the six technology areas.<sup>7</sup> Most of these fields exceed Indiana’s average share of national publications across all research fields of 2.9 percent, suggesting its higher concentration in Indiana. In particular, Indiana stands out in its publications activities associated with:

- Spectroscopy, instrumentation and analytical sciences, which is of particular importance to the technology focus on electro-optics, sensors and surveillance.
- Mechanical engineering, which is a broad research field, with strong alignment to the technology focus areas of warfighter technologies and unmanned aerial systems and robotics.

<sup>7</sup> The Indiana data also includes publications authored by researchers at NSA/NSWC Crane. The articles are primarily found in the Applied Physics/Condensed Matter/Materials Science and Nuclear Engineering disciplines.

- Computer science and engineering, another broad research field, that has connections to many of the technology focus areas, including information technology/computer sciences, sensor and surveillance systems, warfighter technologies and unmanned aerial systems.
- Aerospace engineering, which is involved in the development of advanced electronics used for warfare and unmanned aerial systems.

**Table 5. Key research disciplines and capabilities by technology focus area, 2010–2014.**

Discipline	Indiana Publications 2010–2014	Share of U.S. Publications	Electro-Optics, Sensors and Surveillance	Advanced Electronics	Chemistry Materials	Information Technology/Computer Science	Warfighter Technologies	Aerospace & Unmanned Aerial Systems
Aerospace Engineering	165	4.0%		X				X
AI, Robotics & Automatic Control	411	3.5%					X	X
Applied Physics, Condensed Matter, & Materials Science	2,104	2.6%	X	X	X			
Chemical Engineering	333	3.3%			X			
Chemistry	955	3.4%		X	X			
Computer Science & Engineering	578	4.2%	X			X	X	X
Electrical & Electronics Engineering	692	3.2%	X	X			X	
Information Technology & Communications Systems	371	3.5%				X	X	
Instrumentation & Measurement	261	3.1%	X					
Materials Science & Engineering	738	2.2%		X	X		X	
Mechanical Engineering	858	4.5%					X	X
Nuclear Engineering	146	3.8%		X				
Optics & Acoustics	353	2.5%	X					X
Organic Chemistry & Polymer Science	565	3.0%			X			
Semiconductors & Solid State Materials Technology	397	2.3%	X	X	X			
Signal Processing & Circuits Systems	185	3.7%	X	X		X	X	X
Spectroscopy, Instrumentation, & Analytical Sciences	871	4.6%	X					
Engineering Mathematics	207	3.2%				X		
All Publications, All Disciplines	45,176	2.9%						

Source: Thomson Reuters Current Content Connect Database; Battelle Analysis.

## Examples of Leading Research Centers at Indiana Universities Aligned to the Key Technology Focus Areas Found Across Indiana's Leading Defense Installations

As described above, there is a broad level of alignment between the research and scholarly activities at Indiana's universities to the technology needs of its five core military installations. One specific way in which the research and educational capabilities of Indiana's higher education community can be deployed to support both the mission and growth of the state's key military installations and meet their technology development, deployment, and talent needs is through the operation of specialized centers of research and training in the targeted technology/talent focus areas. The presence of such research centers creates a mutually supportive environment with the state's key military installations by providing a technology-rich environment, which can benefit the operation of the five core installations in a number of ways, including:

- Providing a source of specialized research and technology capabilities of faculty and associated research staff to support the technology development and deployment needs of the installations.
- Generating a source of specialized and tailored educational and training programs that provide the talent needs in the form of the educated and skilled workers needed by the installation.
- Offering specialized, shared use laboratories and equipment, which can complement the research, testing and demonstration activities required by Indiana's military installations.
- Organizing industry consortiums interested in both pre-competitive research as well as specialized contract services, and pursuing commercialization services to advance new discoveries into usable products and services.

Thus, these centers increase local research development capacity, often working with and through local DoD installations. The greater the level of interactions between local academic center installations, the stronger these potential linkages.

In order to assess the presence and potential alignment of academic research and training centers to the technology development, deployment and talent needs of Indiana's five core defense installations, Battelle examined both available federal agency and university web sites to identify the presence of major federally funded research centers at Indiana higher education institutions in each of the six technology focus areas. This assessment also drew to a great extent on academic research and training programs identified in the interviews. While the listing is more illustrative than exhaustive, it does suggest that the Indiana higher education community has the capacity to offer leading centers of research and training in the critical areas technology development, deployment and talent need for the leading Defense five installations analyzed.

### Electro-Optics, Sensors and Surveillance

- Rose-Hulman University offers one of the few Optical Engineering Bachelor's degree program in the country and also offers a Master's degree Optical Engineering. The university's The Center for Applied Optics Studies offers access the specialized faculty and research equipment and has worked with NSWC Crane to demonstrate a wideband optically multiplexed beamforming architecture (WOMBAt). Thus, in the field of optics, the university has been both a source of talent and targeted research capacity for Indiana's core military installations.
- Purdue University's Center for Electronic Defense Systems (CEDS) is dedicated to the advancement of the field of RF/Microwave systems for defense applications. CEDS will utilize a comprehensive

approach to RF engineering which will span from electromagnetics to circuits to waveform synthesis to digital processing with the goal of developing the next generation of RF / Microwave systems.

- Purdue Center for Sensing Science and Technology (CSST) is focused on integrated detection of hazardous materials employing multiple detectors of different types to address concerns about terrorist threats. It has worked closely with NSWC Crane and the Navy's Chemical and Biological In-Service Engineering Agent (ISEA) to develop the next generation and/or improvement of chemical and biological warfare agent point detection and monitoring systems as well as neutron-based detection systems for chemical agents.
- Notre Dame's Wireless Institute was established in January 2010 to leverage Notre Dame's extensive multi-disciplinary experience in advancing wireless technology innovations encompassing antennas; radio frequency (RF) circuits and devices; signal processing and error control coding; network modeling, protocols, and optimization; and mobile applications. Expertise in economics and regulatory policy is also being developed. It involves 16 faculty members, 35 graduate students and over \$2 million in annual research expenditures. Notre Dame as part of its wireless technology efforts is home to an NSF funded multi-university Industry/University Cooperative Research Center known as the Broadband Wireless Access and Applications Center (BWAC) of which the Office of Naval Research is a member. Notre Dame's focus is on "crowded wireless," which includes research into all facets of wireless technology such as crowded devices, crowded spectrum and crowded venues. Specific projects include: heterogeneous networks, multiband radio frequency (RF) circuits, spectrum sharing, user and network analytics, and applications in healthcare and education.

### Advanced Electronics

- Purdue's National Nuclear Security Administration Center for Prediction of Reliability, Integrity and Survivability of Microsystems (PRISM) is focused on accelerating the development of MEMS (micro-electrical-mechanical-systems) technologies for civilian and defense applications as well as to significantly improve the understanding of long-term reliability of MEMS and survivability in harsh environments. It seeks to understand, control, and improve the long-term reliability and survivability of MEMS by using multiscale multiphysics simulation, from atoms to micro-devices, to address fundamental failure mechanisms. The central focus is on a single class of contacting radio-frequency (RF) metal-dielectric capacitive MEMS switches.
- Purdue's Cooling Technologies Research Center is an NSF-funded Industry/University Cooperative Research Center focused on heat removal of electronic systems such as power electronics, transformers, base stations in cellular communications, automotive electronics, portable and wearable electronics, electric vehicle batteries, power distribution systems in computers, and military electronics and avionics. Its industry members include major defense contractors and leading electronics companies from Raytheon to Intel to IBM, among others.
- Purdue leads an NSF-funded Integrative Graduate Education and Research Traineeship (IGERT) program in Sustainable Electronics. It focuses on product design, manufacturing and supply chain approaches for reducing the environmental footprint from traditional design-manufacture-use approaches.
- Notre Dame's Center for Low Energy Systems Technology (LEAST) is one of six university microelectronics research centers funded by the Semiconductor Research Corporation (SRC) and the Defense Advanced Research Projects Agency (DARPA) to support the continued growth and leadership of the U.S. semiconductor industry. LEAST explores the physics of new materials and devices that can lead to more energy-efficient integrated circuits and systems. The research focus is

on ultra-low voltage and steep transistors – transistors that have steep transitions between their on and off state (less than 60 mV/decade of current). It is the successor to an earlier Notre Dame center focused on advancing the tunnel field-effect transistor.

## Chemistry Materials

- IU-Bloomington Center for the Exploration of Energy and Matter is an experimental physics center with a shared-use cyclotron and linear accelerator facility that support a radiation effects research program. It has collaborated with Crane over the years.
- Purdue Center for Thermal Engineering for Military Power Systems focuses on the materials and strategies to meet the unique requirements for directed energy weapons and high-power electromechanical actuators. It pursues a multi-disciplinary research effort spanning materials to systems engineering to address the principal types of thermal loads and critical requirements including low weight and volume, and operation in distributed or centralized modes needed for military systems.
- Purdue Center for Materials Under eXtreme Environment is focused on promoting nuclear, material science, plasma research and education. Members of the CMUXE group perform basic and applied research in a wide variety of interdisciplinary fields. The major thrust area is the interactions of high-intensity, modulated energy beams: electromagnetic radiation, plasma, electrons, ions and other particle sources (i.e., clusters, molecules) with matter. The CMUXE combines advanced integrated computational tools (i.e., HEIGHTS simulation package and state-of-the art experimental devices).
- Purdue Energy Center brings a focused effort in advanced electrochemical systems involving over 20 faculty researchers can significantly change the way we generate, store, and use energy. Projects in this group include development of long-lasting rechargeable batteries with an ultra-fast nanotechnology-based charging process, fuel cells with nano-materials for electrodes and advanced polymer membranes, application of pharmaceutical technology to high speed material screening for batteries and fuel cells, and modeling of battery performance at the molecular level. It works in partnership with various public universities in Indiana, Ivy Tech community college and Crane Naval Surface Warfare Center.
- Notre Dame's Center for Nano Science and Technology (Ndnano) brings an overall focus on advancing more energy-efficient, environmentally friendly and cost-effective technologies made possible with nanotechnology. This includes creating new electronic devices, microsystems and system architectures that can process larger volumes of data using thousands of times less energy, compared to modern information processing systems as well as advancing novel solar energy harvesting and storage technologies from a range of nanomaterials.

## Information Technology/Computer Science

- Indiana University-Bloomington has one of the nation's strongest computer sciences departments. Among its strengths are cybersecurity, computer networking and modeling and visualization. Indiana University is home to the Pervasive Technology Institute, a university-wide research institute launched in 2008 with a 15 year grant of \$15 million by the Lilly Endowment. Its focus is on novel research and innovation and service delivery in the broad domain of information technology and informatics. Current PTI-affiliated Research Centers include:

- Center for Applied Cybersecurity Research (CACR) leads the creation of IT security policy, security tools, and secure applications in critical areas of cyberinfrastructure, including health. CACR is affiliated with PTI, the Maurer School of Law, OVPIT, and UITS.
  - Center for Research in Extreme Scale Technologies (CREST) develops new technologies for high-capability computing systems and applications and exascale computing environments. CREST is affiliated with PTI, the School of Informatics and Computing, the OVPIT, and UITS.
  - Data to Insight Center focuses on the life cycle of digital data while furthering tools for discovering and gaining insight from the vast quantities of data now produced in digital form. D2I is affiliated with PTI, the School of Informatics and Computing, OVPIT and UITS, and works closely with the IU Libraries.
  - Digital Science Center (DSC) advances cloud computing and network science and is home to the well-known FutureGrid. DSC is affiliated with PTI, the School of Informatics and Computing, and OVPIT.
- Purdue's Cyber Center provides a venue for all IT-related research, hardware, software, and staffing to come together in a single venue allowing new discoveries that can have immediate impact on discovery, learning, and engagement. It leverages the expertise of existing groups on campus, including the Indiana Center for Database Systems (ICDS), the Rosen Center for Advanced Computing (RCAC), the Purdue Regional Visualization and Analytics Center (PURVAC), the Computer Research Institute (CRI), and the Network for Computational Nanotechnology (NCN) to build tightly coupled teams to address the major areas of cyberinfrastructure research challenges. Among ongoing research focus areas within the Cyber Center are:
    - High-end Computing, including novel parallel computer architectures, associated compilers and systems software and parallel numerical algorithms, and benchmarking and performance evaluation of tools.
    - Applications and Middleware, involving research in Web services, semantic Web, and Grid services, as well as providing computation as a utility, and in establishing scientific research grids for Cyber Infrastructure activities with access through the TeraGrid.
  - Ball State is the lead university in a long-standing NSF funded Industry/University Cooperative Research Center for software engineering, which recently has added a focus on information/network security. Known as S2ERC, it engages with companies and government agencies, including U.S. military and other U.S. government organizations, from diverse fields such as military contractors, financial providers, the insurance sector, information and network technology leaders, web technology firms, heavy equipment manufacturers, and large conglomerates. Recent S2ERC research projects have focused on these issues: intrusion detection, ad-hoc network security, wireless security, attack-tolerant systems, trustworthiness in cloud and mobile applications, security & vulnerability analyses, information protection, requirements capturing, software design, software metrics, software feature analysis, software testing, software reliability, user interface design, usability issues, global software development, migrating software to multi-core architecture, visualization environments, interactive collaborative environments, dynamic & static analyses, and testing and model checking for concurrent programs.
  - Indiana has three higher education institutions designated Centers of Academic Excellence in cybersecurity education and/or research designated by the National Security Agency and the Department of Homeland:

- Ivy Tech Community College's Cyber Security and Information Assurance program is designated as a National Center of Academic Excellence in Information Assurance 2-Year Education;
- Indiana University's is designated as Center for Applied Cybersecurity Research has been designated a Center of Academic Excellence in both Information Assurance Research and Education; and
- Purdue's Center for Education and Research in Information Assurance and Security (CERIAS) is designated as a Center of Academic Excellence in Information Assurance Research.

### Warfighter Technologies

- This area is highly specialized and applied focus to meet the needs of warfare systems for special forces operations and overlaps with other technology areas including electro-optics, wireless communications, electronics and chemistry-materials, which Indiana's universities are actively involved.

### Unmanned Aerial Systems

- Indiana State University is building upon its expertise in its Department of Aviation Technology to advance new educational and applied technology development opportunities in unmanned systems. The university already offers courses on unmanned systems operations and a study of advanced unmanned aircraft theory that addresses UAS modeling and control fundamentals, ground based systems, visual and electro-optical aspects of navigation, obstacle and terrain avoidance systems, modular on-board processing systems, and regulations impacting the unmanned systems operations. Students gain specific skills in UAS programming, preflight, flight operations, post flight inspection, and mission analysis and debriefing. Through its Center for Unmanned Systems and Human Capital Development, the Indiana State is leveraging its Center for Homeland Security and Crisis Leadership and the Department of Aviation Technology to develop a unique approach to developing leaders and experiential learning activities involving the uses of unmanned aerial systems.
- Purdue has a growing focus on unmanned aerial systems education and research. Through its Department of Aviation Technology, Purdue has a range of courses in unmanned aerial systems design, construction, inspection, repair, applications and flight training. Through Purdue's Center for Integrated Systems in Aerospace (CISA), an interdisciplinary research center lead by faculty in its Department of Aviation Technology, researchers are advancing the theory and application of methods for modeling interactions, controlling integration, and optimization in complex systems (vehicles, platforms, humans) and information management for collaboration in systems-of systems (e.g., missile defense, transportation, network-enabled architectures, etc.), including UAS vehicle modeling and UAS networks and integration into the airspace.

### Paradox of Lower Level and Growth in DoD Research Funding for Indiana Universities

Despite the strong position and growing base of university research funding in key fields aligned with the technology focus areas of Indiana's leading defense installations, Indiana universities receive a substantially smaller share of their funding from the Department of Defense (not limited to just Indiana

installations), The federal sources of funding by agency for academic research fields are also tracked by the National Science Foundation. In 2013, NSF reports that Indiana universities receive 11.0 percent of their total funding in the ten aligned academic research fields from the Department of Defense.<sup>8</sup> By comparison, the national average across the ten academic research fields was 23.5 percent of funding coming from DoD support.

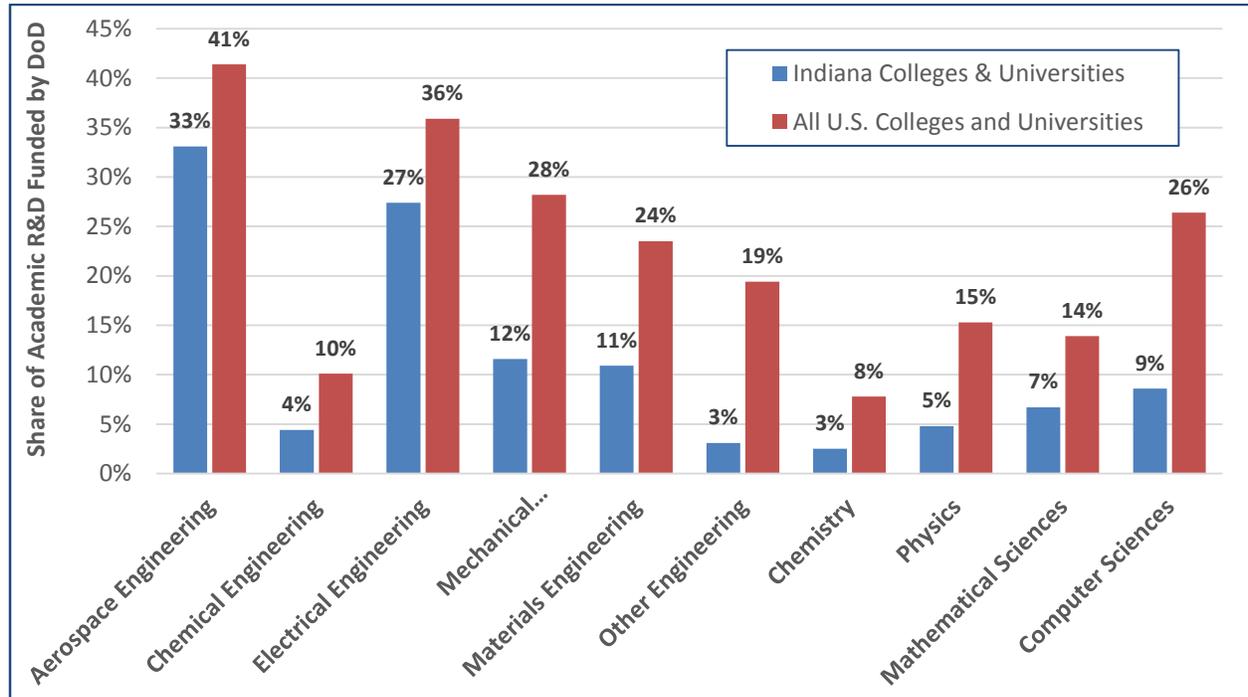


Figure 3. Share of aligned academic research fields R&D Funded by DoD, 2013.

Source: National Science Foundation Higher Education Research and Development Expenditures, 2013 and Battelle analysis.

Furthermore, while Indiana universities are growing in their DoD support for science and engineering research funding, they have not kept pace with overall DoD support to universities. From 2010 to 2013, federal DoD funding for university science and engineering research grew nationally by 12.5 percent, but only 1.6 percent for Indiana. This lagging performance is not limited to just the most recent period, but has been lagging consistently since 2009 as shown in Figure 4.

<sup>8</sup> These data represent funding from all branches/operations of DoD from across the U.S., not just from the Indiana DoD installations.

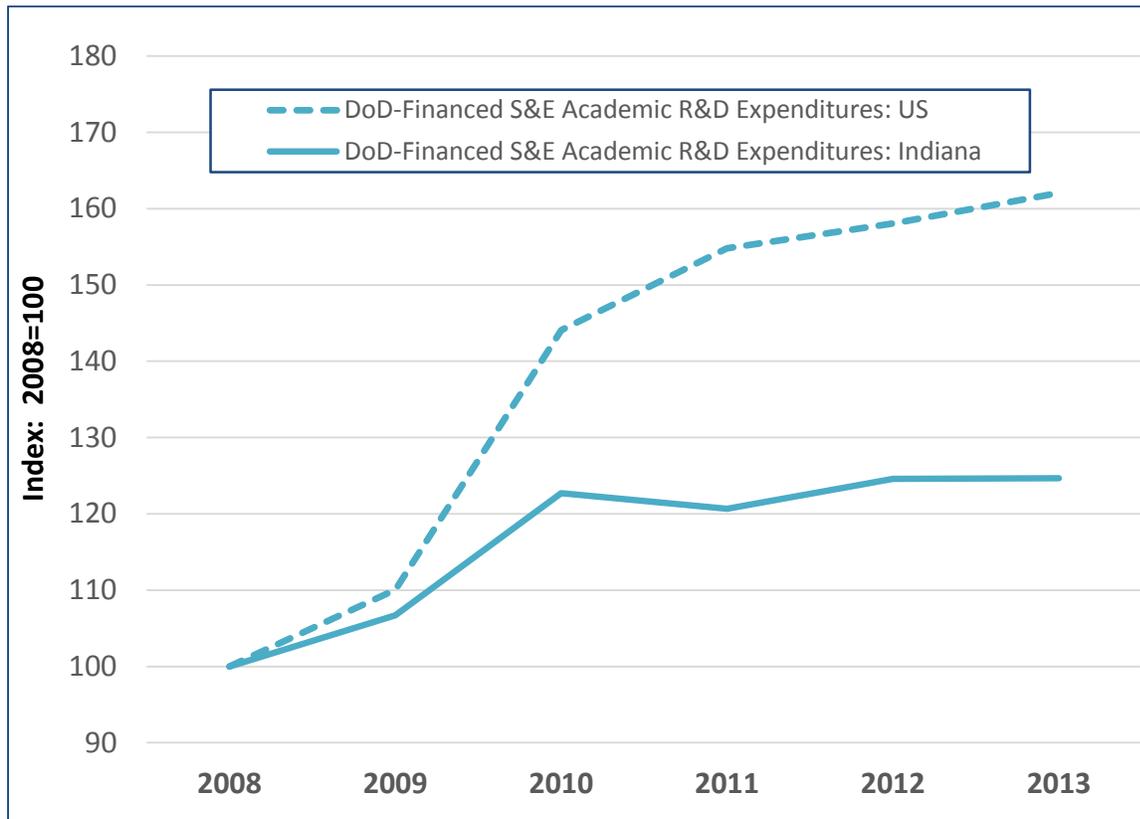


Figure 4. Indexed Growth of Department of Defense Funding for University Science and Engineering Research: Indiana and the United States.

Source: National Science Foundation Higher Education Research and Development Expenditures, 2008–2013 and Battelle analysis.

The situation of Indiana universities having a broad level of alignment with the technology needs of its Indiana’s leading defense installations, yet falling short in the level and growth of DoD research funding needs is a paradox. The implication is that more focused efforts are needed in Indiana to aggressively pursue DoD funding based on the growing strengths of Indiana’s universities in key research fields aligned to the targeted technology/talent focus areas are required.

## Section 4. Talent Generation Alignment of Indiana's Higher Education Capabilities to the Workforce Needs of Indiana's Five Core Military Installations

Access to skilled science, technology, engineering and mathematics (STEM) workers is also vital to our national defense. Colleges and universities are not only sources of new technological innovations; their core mission is the provision of a skilled and educated workforce. As the leading generators of a STEM workforce, colleges and universities can play a vital role in supporting national defense and the operations of local military installations. The importance of STEM education to national defense is made clear by the *2012 Assuring the U.S. Department of Defense a Strong Science, Technology, Engineering, and Mathematics (STEM) Workforce* report which found that "Science and technology and the DoD STEM workforce are increasingly critical to U.S. military capability" and that "Access to highly qualified STEM talent should be a primary consideration in DoD workforce recruitment and retention policies, guidelines, and practices."<sup>9</sup>

While the DoD operates its own system of undergraduate and graduate education, it relies on public and private higher education for a significant share of its STEM needs especially at the graduate degree level. This reliance is demonstrated in the following quote from the *2014 Review of Specialized Degree-Granting Graduate Programs of the Department of Defense in STEM and Management* report which found that:

"DOD depends on these civilian institutions to educate the majority of its civilian workforce and military members. In addition to providing the opportunity to learn from world-renowned faculty members, civilian institutions offer degrees in disciplines not available at DOD-funded institutions, particularly in law, medicine, life sciences, and social sciences. The large number of civilian institution options creates a diversity of perspectives and ideas that strengthen the DOD workforce and military members, as well as the military and civilian faculty of DOD-funded educational institutions."<sup>10</sup>

In order to assess the role of Indiana's higher education system in meeting these talent needs, Battelle assessed the role of Indiana higher education in providing the skilled and educated workforce required by Indiana's defense community, with a focus on the five core installations. This analysis focused on the key occupational classifications of critical importance to each of the six targeted technology focus areas as well as other key talent/workforce related areas identified as areas of significant need by the installations themselves. Battelle conducted two analyses:

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<sup>9</sup>National Academy of Engineering and National Research Council, *Assuring the U.S. Department of Defense a Strong Science, Technology, Engineering, and Mathematics (STEM) Workforce* available from The National Academies Press at [http://www.nap.edu/catalog.php?record\\_id=13467](http://www.nap.edu/catalog.php?record_id=13467), Page 6.

<sup>10</sup> National Research Council, *Review of Specialized Degree-Granting Graduate Programs of the Department of Defense in STEM and Management*, National Research Council, [http://www.nap.edu/catalog.php?record\\_id=18752](http://www.nap.edu/catalog.php?record_id=18752), Page 3.

1. An analysis of recent overall trends in DoD, Department of the Air Force, Department of the Army, and Department of the Navy employment and hiring, with a specific focus on the technology areas central to this analysis; and
2. An analysis of degrees awarded in key educational fields related to the six specific technology foci that are central to the technology development and deployment requirements and of the five military installations analyzed.

### Department of Defense Employment in Indiana is becoming more focused on Technical Fields and Increasingly Requires a College or Advanced Degree

As noted earlier, the direct DoD employment in Indiana has increased since 2007 and now exceeds over 10,000 jobs. Table 6 provides a breakdown in change in employment between 2007 and 2014 for selected occupations. Approximately, 44 percent of these jobs are part of the Team Crane (NSA Crane) operations (including Naval Surface Warfare Center (NSWC) Crane, Crane Army Ammunition Activity (CAAA), and other operations), and an additional one-third of these jobs are part of the Defense Finance and Accounting Services (DFAS) operations in Indianapolis.

**Table 6. Indiana Department of Defense related employment change for selected occupations.**

Occupational Area	2007	% of Total	2014	% of Total	# Change	% Change
<b>Total Employment</b>	<b>9,187</b>	<b>100%</b>	<b>10,395</b>	<b>100%</b>	<b>1,208</b>	<b>13.1%</b>
<b>White Collar Employment</b>	7,501	82%	8,918	86%	1,417	19%
Accounting And Budget	2,620	29%	3,037	29%	417	16%
Engineering And Architecture	1,709	19%	1,880	18%	171	10%
Engineering Technical	255	3%	221	2%	(34)	(13%)
Mechanical Engineering	226	2%	312	3%	86	38%
Electric, Computer and Electronics Engineering	593	6%	756	7%	163	27%
Electronics Technical	499	5%	413	4%	(86)	(17%)
Other Engineering and Architecture	136	1%	178	2%	42	31%
Physical Sciences	52	1%	82	1%	30	58%
Information Technology	439	5%	872	8%	433	99%
Logistics (Supply and Transportation)	317	3%	325	3%	8	3%
Other White Collar	2,364	26%	2,722	26%	358	15%
<b>Blue Collar/Unspecified</b>	1,686	18%	1,477	14%	(209)	(12%)

Source: U.S. Office of Personnel Management, FedScope, Employment Cubes.

Much of the growth in the DoD-related employment is in higher skilled occupations with:

- Employment of Information Technology occupations nearly doubling since 2007 representing an increase of 433 jobs;
- Employment in Physical Sciences occupations increasing by 58 percent since 2007;
- More than one in ten DoD-related jobs being in Engineering and Architecture occupations, with strong demand for Electric, Computer, and Electronics Engineering occupations; and,
- Within Engineering Occupations there has been a transition from lower skilled Engineering Technical and Electronics Technical occupations, which are often lower level technician jobs, to more skilled, degreed engineering positions.

The DoD and Military Services are demanding more highly educated workers in Indiana. As presented in Table 7, nearly half of DoD-related employees in Indiana have a Bachelor's degree or above and 15 percent have an Advanced degree. The number of DoD-related Indiana workers with less than a Bachelor's degree has fallen, while employment of individuals with graduate degrees has expanded. DoD related employment of persons with a Master's Degree increased by more than fifty percent and employment of persons with a Doctorate or above more than doubled. **Based on recent employment activity, it is clear that Indiana's DoD installations are requiring educated workers with a bachelor's or even an advanced degree.**

**Table 7. Change in Indiana Department of Defense employment, by level of educational attainment.**

Educational Level	2007 Count	% of Total	2014 Count	% of Total	# Change	% Change
<b>Total</b>	<b>9,187</b>	<b>100%</b>	<b>10,395</b>	<b>100%</b>	<b>1,208</b>	<b>13%</b>
Below High School	54	1%	33	0%	(21)	(39%)
High School Or Equivalency	3,160	34%	3,175	31%	15	0%
Occupational Program	299	3%	170	2%	(129)	(43%)
Associates Degree	775	8%	863	8%	88	11%
Some College - no Degree	1,471	16%	1,226	12%	(245)	(17%)
Bachelors	2,212	24%	3,151	30%	939	42%
Post-Bachelors	173	2%	184	2%	11	6%
Masters	961	10%	1,451	14%	490	51%
Post Masters	27	0.3%	39	0.4%	12	44%
Doctorate	39	0.4%	93	0.9%	54	138%
Post-Doctorate	5	0.1%	5	0.0%	0	0%
Unspecified/Not Reported	11	0.1%	5	0.0%	(6)	(55%)

Source: U.S. Office of Personnel Management, FedScope, Employment Cubes.

A preliminary occupational needs assessment for Indiana's largest and most technologically advanced defense installation, NSWC Crane, points to the range of skills that are expected to be needed in the

years ahead. It is estimated that for current operations over the next five years, NSWC Crane will be hiring approximately 200–250 new employees annually across the following categories:<sup>11</sup>

- 50% of the hirings will be in engineering and scientific occupations, such as electronics engineers, mechanical engineers, computer scientists/engineers, chemical engineers, and physicists, among others. Some will be hired at the masters and PhD level, but the majority will be hired for entry level positions requiring bachelor's degrees.
- 25% will be in business and accounting fields involving contracts/purchasing specialists, program and research analysts, accountants and financial management analysts. Accountants and contracts specialists require bachelor's degrees while purchasing agents, program and financial analysts may be filled by those with specialized experience and associate's degrees.
- 15% of the hirings will be for technical and industrial technicians requiring certifications or associates degrees.
- The remaining 10% will involve a range of specialty areas involving integrated logistics support and broader information technology specialists as well as human resource professionals, safety specialists and others.

### **Talent Generation in Targeted Degree Areas Aligned with Technology Focus Areas of Indiana's Leading Defense Installations**

The growing demand for highly educated workers at Indiana's defense installations is not surprising given the presence of the six technology focus areas identified across Indiana's leading defense installations. One way to take a more in depth look at the alignment of higher education talent generation in Indiana across the core technology focus areas is to consider specific degree generation and the quality of educational degrees found in Indiana.

As set out in Table 8, Battelle mapped educational degrees, as defined by the Federal Classification of Instructional Programs (CIP) at the associate, bachelor, and graduate level, to each of the six technology focus areas. The data on number and trends in the degrees awarded was obtained from the National Center of Educational Statistics (NCES) at the U.S. Department of Education, which collects such information from every postsecondary institution in the nation.

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<sup>11</sup> Prepared for the Workforce Development and Education Subcommittee for the Southwest Central Indiana Regional Plan, December 2014

**Table 8. Crosswalk of educational degrees to the core technology focus areas of Indiana’s leading defense installations.**

Degree Area	Electro-Optics, Sensors and Surveillance	Advanced Electronics	Chemistry Materials	Information Technology/ Computer Science	Warfighter Technologies	Aerospace & Unmanned Aerial Systems
<b>Computer Science and Information Technology – All</b>	X	X		X		
<b>Engineering/Engineering Technology – Total</b>						
Aerospace – Aeronautical and Astronautical Engineering						X
Chemical Engineering			X		X	
Computer Engineering – General				X		X
Computer Software Engineering				X		X
Electrical – Electronics and Communications Engineering	X	X		X		
Elect/Electronic/Comm Technology/Technician	X	X				
Aeronautical/Aerospace Eng. Technology/Technician	X	X				X
<b>Physical Sciences</b>						
Chemistry			X		X	
Physics	X	X				
<b>Airframe/Aircraft/ Avionics Technicians</b>						X
<b>Aeronautics/Aviation/Aerospace Technology – Other</b>						X

**Overall, Indiana is well positioned to meet the talent/workforce demand of DoD for more highly educated workers in computer, engineering, and scientific fields.** As presented in Figure 5, Indiana has experienced strong growth in the number of degrees awarded across the targeted computer, engineering, and scientific fields, with especially strong growth in the Computer and Information Sciences and Support Services degree areas.

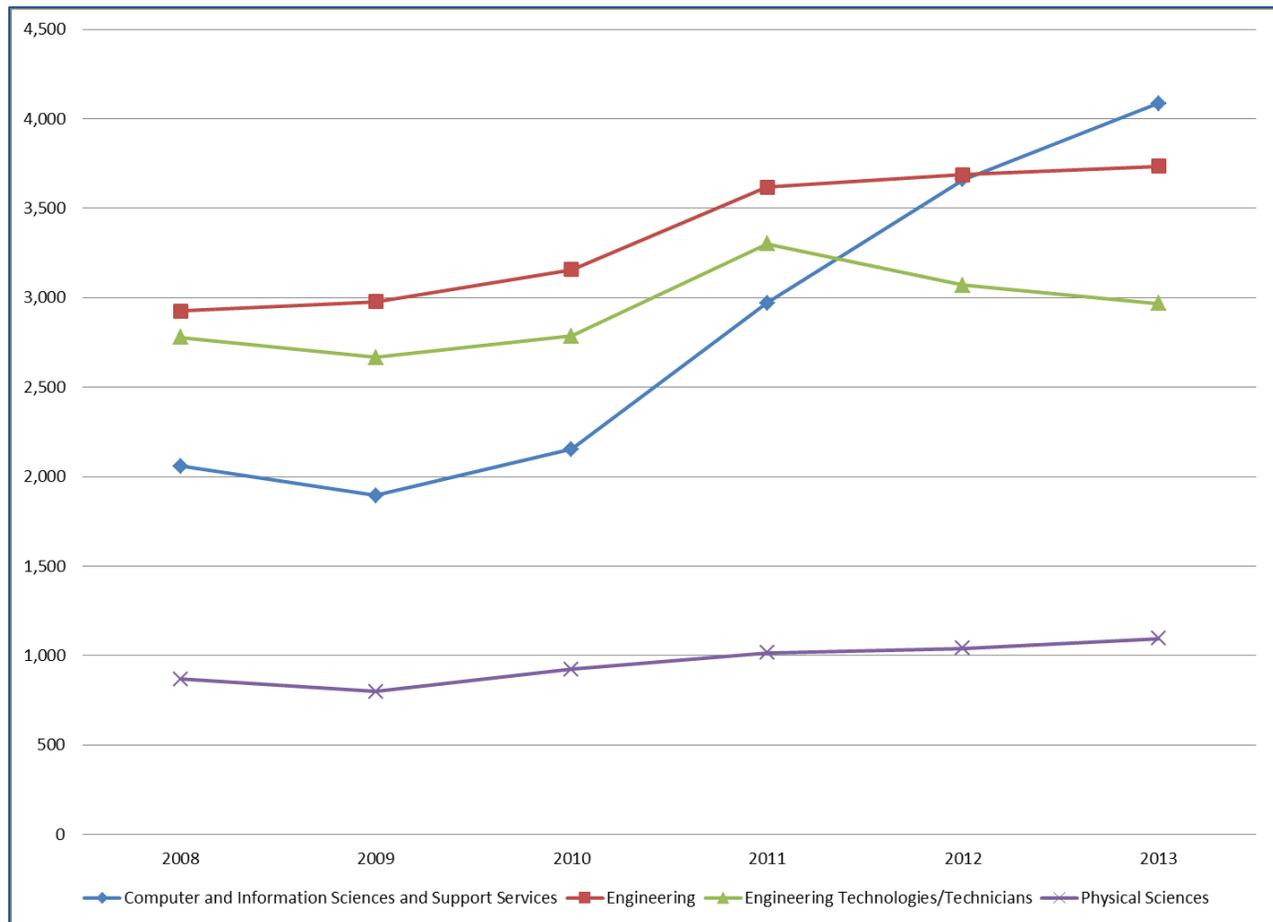


Figure 5. Trends in degrees granted in target talent degree areas.

Source: National Center for Educational Statistics.

**For both Bachelor's and graduate degrees awarded by Indiana's higher education system, there is a generally strong alignment between degrees granted and the workforce needs of the five installations analyzed.** As Table 9 indicates, Indiana has experienced strong growth in the levels of degrees awarded in the targeted areas of defense installation talent/workforce need, with:

- Strong growth in Computer Science degrees at the Bachelor's and especially at the Graduate degree levels;
- Continuing strong generation and growth in Engineering degrees granted, including both large numbers of both degrees granted and growth in the Aerospace - Aeronautical and Astronautical Engineering and Electrical - Electronics and Communications Engineering degree fields that were identified as important in both the interviews and analysis of DoD-related employment; and
- High degree generation and growth in Physical Sciences degrees.

**Table 9. Trends in Bachelors and Advanced Degrees awarded in in key selected summary areas and selected detailed degree areas.**

Degree Area	Bachelor's Degree			Advanced Degree		
	2013 Count	# Change 2008–13	% Change 2008–13	2013 Count	# Change 2008–13	% Change 2008–13
<b>Computer Science and Information Technology – All</b>	<b>1,464</b>	<b>422</b>	<b>40%</b>	<b>369</b>	<b>229</b>	<b>164%</b>
<b>Engineering/Engineering Technology – Total</b>	<b>3,687</b>	<b>636</b>	<b>21%</b>	<b>1,330</b>	<b>408</b>	<b>44%</b>
Aerospace - Aeronautical and Astronautical Engineering	196	56	40%	111	47	73%
Biomedical/Medical Engineering	130	49	60%	42	21	100%
Chemical Engineering	272	116	74%	53	(2)	(4%)
Computer Engineering - General	140	(14)	(9%)	23	7	44%
Computer Software Engineering	39	10	34%	1	1	n.m.
Electrical - Electronics and Communications Engineering	403	75	23%	200	(4)	(2%)
Elect/Electronic/Communications Technology/Technician	195	29	17%	16	(10)	(38%)
Aeronautical/Aerospace Eng. Technology/Technician	0	n.m.	n.m.	0	n.m.	n.m.
<b>Physical Sciences</b>	<b>795</b>	<b>173</b>	<b>28%</b>	<b>280</b>	<b>39</b>	<b>16%</b>
Chemistry	480	100	26%	137	17	14%
Physics	194	69	55%	80	(1)	(1.2%)
<b>Airframe/Aircraft/Avionics Technology/Technicians</b>	<b>17</b>	<b>15</b>	<b>750%</b>	<b>0</b>	<b>n.m.</b>	<b>n.m.</b>
<b>Aeronautics/Aviation/Aerospace Technology</b>	<b>171</b>	<b>(20)</b>	<b>(10%)</b>	<b>17</b>	<b>17</b>	<b>n.m.</b>

Source: National Center for Educational Statistics.

One area of a slight decline in enrollment was in Aeronautics/Aviation/Aerospace Technology, which includes Aeronautics/Aviation/Aerospace Science and Technology, Airline/Commercial/Professional Pilot and Flight Crew, and Aviation/Airway Management and Operations degrees, with small decline in Bachelor's degrees granted, but growth in Advanced degrees granted. Given the importance of aerospace both to the five installations analyzed and to the defense industry in Indiana overall, where it is the largest area of procurement activity, this area warrants further investigation.

Two additional areas of workforce need were identified in the interviews but were not included in the analysis of degrees granted above. The first was *medical personnel*, ranging from nurses to flight surgeons, to serve military personnel and support the overall mission of the various installations. Because defense-related employment of medical personnel is a relatively small share of overall in-state demand, trends in degrees awarded in medical fields was not included in the analysis above, but is highlighted

here in the report. Similarly, several of the key informants interviewed identified **logistics related personnel** as an area of occupational need. Despite the presence of several nationally recognized logistics related programs in Indiana colleges and universities, including programs at Purdue and Indiana University – Bloomington, there was a low level of degrees granted in programs identified as such in the data that was analyzed. Presumably, this field is an area of specialization within a broader business or related degree and cannot be analyzed independently. As a result, these two areas of need are described here but not included in the above analysis of degrees granted.

**While overall Indiana DoD employment growth has been strongest for workers with a Bachelor's Degree or above, the DoD still needs workers in occupations requiring less than a Bachelor's degree.** Approximately 8 percent of the DoD-related workforce in Indiana has an Associate's degree, with this level remaining stable since 2007. The need for workers with associate's degrees was made explicitly clear in the installation interviews, where aircraft/aerospace/avionics, communications, electrical and electronic technicians were identified as specific areas of need. Based on the DoD occupational employment analysis, demand for engineering and electronics technicians has fallen somewhat since 2007, but this does not consider the need for replacement workers for those retiring. Based on interviews conducted, Indiana's core military installations have a strong level of demand for these workers, especially in the areas of *electrical, electronics, and communications technicians, and aerospace, aircraft and avionics technicians.*

For Associate's degrees, outside of computer sciences, many of the technical degrees aligned to the technology focus areas has declined, especially in electrical, electronics, and communications technicians, and aerospace, aircraft and avionics technicians. This is a potential area of opportunity to improve the alignment between Indiana's higher educational system and the needs of its leading defense installations.

**Table 10. Trends in Associates Degrees awarded in in key selected summary areas and selected detailed degree areas.**

Degree Area	Associates Degree			
	2008 Count	2013 Count	# Change	% Change
Computer Science and Information Technology – All	601	1,113	512	85%
Engineering/Engineering Technology – Total	1,412	1,095	(317)	(22%)
Physical Sciences	40	63	23	58%
Airframe/Aircraft/Avionics Technology/Technicians	148	52	(96)	(65%)
Aeronautics/Aviation/Aerospace Technology	27	13	(14)	(52%)

Source: National Center for Educational Statistics

**At the level of bachelor and graduate level degrees, not only is there a strong overall level of alignment of the degree program areas of Indiana's higher education system and the talent needs of its key defense installations, the quality of Indiana's higher education community is evident in the number of accredited and nationally ranked programs offered in degree areas essential to Indiana's five key defense installations.**

According to ABET, a nonprofit, non-governmental organization that accredits college and university programs in the disciplines of applied science, computing, engineering, and engineering technology, Indiana's higher education system offers a large number of accredited programs in the key defense technology focus areas:

**Aerospace, Aeronautical, and Astronautical Engineering** with Indiana having two accredited schools, Purdue University at West Lafayette and University of Notre Dame.

**Biological and Biomedical Engineering** with Indiana having four accredited schools, Indiana Institute of Technology, Indiana University - Purdue University Indianapolis, Purdue University at West Lafayette and Rose-Hulman Institute of Technology.

**Chemical Engineering** with Indiana having four accredited schools, Purdue University at West Lafayette, Rose-Hulman Institute of Technology, Trine University, and University of Notre Dame.

**Computer and Software Engineering** with Indiana having eleven accredited schools, Indiana State University, Indiana University - Purdue University Indianapolis, Indiana University-Purdue University Fort Wayne, Purdue University at West Lafayette, Purdue University Calumet, Rose-Hulman Institute of Technology, Taylor University, Trine University, University of Evansville, University of Notre Dame, and Valparaiso University.

**Electrical Engineering** with Indiana having eleven accredited schools, Indiana Institute of Technology, Indiana University - Purdue University Indianapolis, Indiana University-Purdue University Fort Wayne, Purdue University at West Lafayette, Purdue University Calumet, Purdue University North Central, Rose-Hulman Institute of Technology, Trine University, University of Evansville, University of Notre Dame, and Valparaiso University.

**Computer Science** – All Programs with Indiana having six accredited schools, Indiana University - Purdue University Indianapolis, Indiana University-Purdue University Fort Wayne, Purdue University Calumet, Rose-Hulman Institute of Technology, University of Evansville and University of Notre Dame.

**Indiana's higher education community offers access to many of the top ranked institutions in academic quality for the key technology focus areas found across Indiana's leading DoD installations.** Below is a selection of relevant national rankings from the U.S. News and World Report presented below:

- Purdue University – West Lafayette is ranked as the 62<sup>nd</sup> best national university, with the 9<sup>th</sup> best overall undergraduate engineering program nationally, and its graduate engineering program is ranked 8<sup>th</sup> nationally with a ranking in the top twenty institutions in all engineering specialties including aerospace/aeronautical/astronautical 5<sup>th</sup>, biomedical 17<sup>th</sup>, chemical 11<sup>th</sup>, computer 13<sup>th</sup>, and electrical/electronic/communications 9<sup>th</sup> – all areas of identified talent need among Indiana's key military installations. Purdue – West Lafayette is also ranked 10<sup>th</sup> nationally in the undergraduate business degree area of supply chain management/logistics, and its graduate programs are ranked 20<sup>th</sup> in computer science, 21<sup>st</sup> in chemistry and 44<sup>th</sup> in physics.

- Indiana University – Bloomington is ranked 76<sup>th</sup> overall among all universities nationally, and is ranked among the top universities nationally in the undergraduate business degree area of supply chain management/logistics 13<sup>th</sup>, and in the area of graduate programs, it is ranked 24<sup>th</sup> in chemistry, 39<sup>th</sup> in physics, and 52<sup>nd</sup> in computer science.
- Indiana University-Purdue University—Indianapolis is ranked as the 100<sup>th</sup> best undergraduate engineering schools nationally at schools that offer a doctorate and its graduate engineering program is ranked 65<sup>th</sup> nationally in biomedical engineering and 97<sup>th</sup> in computer engineering.
- Rose-Hulman Institute of Technology was tied for a first place ranking nationally in the ranking of undergraduate engineering programs in programs where a doctorate is not offered.
- University of Notre Dame – is ranked 16<sup>th</sup> overall among universities nationally, and is ranked 36<sup>th</sup> among the top universities nationally in undergraduate engineering. Its graduate engineering program is ranked 46<sup>th</sup> nationally with high national rankings in aerospace/aeronautical/astronautical 21<sup>st</sup>, chemical engineering 28<sup>th</sup>, computer engineering 44<sup>th</sup> and electrical/electronic/communications 48<sup>th</sup>.

## Summary

Indiana appears to be well positioned to meet the talent requirements of its growing base of DoD activities. Indiana's higher education community is particularly well-aligned in the growing areas of DoD-related employment opportunities for bachelor and graduate level degrees. The state offers access to highly accredited and some of the top ranked programs in key engineering, scientific and computer fields, with strong focus on the state's aerospace, electronics and computing talent needs.

The one area for improvement is in more Associate degree level technical skill areas. Indiana's core defense installations identified a strong level of demand for these workers, especially in the areas of *electrical, electronics, and communications technicians*, and *aerospace, aircraft and avionics technicians*, which have declined in Associate Degrees awarded in recent years.

## Section 5. Implications of Findings

Looking forward, this assessment suggests that there are opportunities for pursuing new collaborative efforts to better connect the existing Indiana university research strengths to DoD opportunities, and to pursue more collaborative program development at the Associate Degree level for specific technical fields.

### Better Leveraging University Research Strengths for DoD Opportunities

The alignment of higher education research and development activities to the technology focus areas identified across Indiana's leading defense installations presents a paradox. Indiana's academic research, as represented by funding, papers and research centers, offers a significant and growing research base in fields aligned with the technology focus areas of Indiana's leading defense installations. Yet, DoD support for academic R&D in Indiana, while increasing since 2008, accounts for a smaller share of total funding across all aligned disciplines and has not kept pace with overall DoD support to universities.

The implication is that more focused efforts are needed in Indiana to aggressively pursue DoD funding based on the growing strengths of Indiana's universities in key research fields aligned to the targeted technology/talent focus areas are required. Examples from other states suggest that state efforts can leverage as well as enhance important capabilities to spur increasing university-DoD collaborations.

One excellent example is the efforts in Huntsville, Alabama to further the alignment of university research with its major defense installation, the Redstone Arsenal, a leading DoD center for rocket research and development. NASA also located its center for rocket development, Marshall Space Flight Center, in Huntsville roughly a decade later. Nearly two decades after the establishment of the Redstone Arsenal as a DoD technology center, the State of Alabama created a new independent research campus of the University of Alabama. In the years since, the University of Alabama in Huntsville has grown into a robust research university, with \$99 million in funded research. It specializes in a number of research fields critical to space and rocket R&D, including:

- Aerospace engineering with \$39 million in research funding for 2013, growing from \$11.2 million in 2008.
- Computer sciences with \$25.3 million in research funding for 2013, growing from \$14.4 million in 2008.
- Atmospheric sciences with \$8.7 million in research funding for 2013.

The University of Alabama in Huntsville (UAH) has also focused on establishing key centers of excellence, often in collaboration with other universities. A longstanding center is the Rotorcraft Systems Engineering and Simulation Center for systems engineering, rapid prototyping and fabrication with associated lab facilities. UAH is also a member of a University-Affiliated Research Center for Systems Engineering Research, led by Stevens Institute for Technology and University of Southern California. Recently, UAH is focusing on developing an Aviation Technology Center of Excellence to complement the recent relocation to Redstone Arsenal of the U.S. Army Aviation Technical Test Center and the continued work of the U.S. Army Aviation and Missile Command.

Another excellent example is the efforts under in Ohio to better leverage university research strengths from across the state in furthering the mission of Wright Patterson Air Force Base, main home of the Air Force Research Labs. One notable university collaboration has been the establishment of the Institute for the Development and Commercialization of Advanced Sensor Technology (IDCAST) as a Wright Center of Innovation through a \$28 million Ohio Third Frontier award. IDCAST is a center of excellence in remote sensing. Located in Dayton's Tech Town business park, IDCAST provides collaborative lab space, research facilities and incubator space for startup companies, enabling access to sensor test-beds and other cutting-edge equipment. Another collaborative university effort in Ohio is the Wright Brothers Institute. Originally conceived in 2001 as a unique partnership with the Air Force Research Laboratory (AFRL) using a Partnership Intermediary Agreement (PIA) for "Aerospace Collaboration and Technology Transfer". Under this agreement, WBI facilitated endowed chairs at regional universities in areas of high technical interest to AFRL. This idea evolved in 2008 into the creation of the Tec^Edge Innovation & Collaboration Center (ICC), a rapidly reconfigurable environment for government, university, and industry teams to explore challenging problems in national defense and public safety. Tec^Edge ICC has hosted and facilitated innovation and collaboration workshops for AFRL and began operation of AFRL's Halo telepresence studio. In addition, the AFRL Center for Rapid Product Development began operations at Tec^Edge Works.

### Addressing Technical Skill Needs

Overall, Indiana's higher education community is particularly well-aligned in the growing areas of DoD-related employment opportunities for a skilled workforce. Indiana offers access to top ranked programs in key engineering, scientific, and computer fields.

One area for improvement identified was for more Associate degree level technical skill areas involving *electrical, electronics, and communications technicians, and aerospace, aircraft and avionics technicians*. Many of Indiana's leading defense installations identified this as a specific workforce need. Overall, outside of computer sciences, the level of Associate's degrees awarded in the targeted defense-related degree areas has declined, especially in key technical and technician programs.

This suggests an opportunity for a targeted skill center initiative with the Ivy Tech Community College system. According to the National Governors Association Cluster Strategies report, such centers offer a resource to industry that can understand a cluster's particular needs and interests, solve problems, assure a continued flow of qualified workers, and serve as a source of skill upgrading for the incumbent workforce. It also allows students access to better and deeper programs ("know what"), better employment information and more rungs on career ladders ("know who"), deeper understanding of industry context ("know why"), and more informal learning opportunities ("know how").<sup>12</sup> Community colleges are often the site for such industry-driven technology and workforce development centers, but four-year colleges and universities also can be key sites or partners. Examples of efforts in targeted skill areas related to defense needs includes:

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<sup>12</sup> National Governor's Association, Cluster-based Strategies for Growing State Economies, Prepared as part of Innovation America Initiative in collaboration with the Council on Competitiveness, page 16.

- The Robotics Corridor Consortium in Pennsylvania, comprised of education, government and industry partners, is advancing a Robotics Educational Resource Center. This Center has attracted both state and local foundation support, as well as a \$790,000 grant from the National Science Foundation Advanced Technical Education (NSF-ATE) program to collaborate with Northwest Ohio. Butler County Community College in Southwest Pennsylvania as part of the Robotics Corridor efforts is now offering a Robotics Technology Associate Degree, designed to prepare graduates for immediate employment as an electronic engineering technician, including work on unmanned aerial systems. A key component of the Robotics Corridor Consortium's NSF-ATE funding is advancing new curriculum for Cuyahoga Community College in Cleveland based on Department of Defense-funded technician-level training materials as well as exemplary curriculum from Carnegie Mellon University. A key objective of this effort is also to improve community college faculty competency, along with that of collaborating High School teachers, in robotics-related education and training. There is also a strong STEM outreach component to this NSF-ATE grant working with the Cleveland Municipal School District.
- In Maryland, Anne Arundel Workforce Development Corporation, the local federally-supported workforce investment board, has worked closely with the Anne Arundel Community College in advancing cybersecurity training. Back in 2010, it received a \$4.9 million grant to train workers for the U.S. Cyber Command, a new unit headquartered at Fort Meade, Maryland. It helped advance the Cyber Center and its training center at Anne Arundel Community College, which is designated by the National Security Agency and the Department of Homeland Security as a national center for information assurance education. More recently the state has supported the planning and implementation of the Central Maryland Cyber/IT Consortium. This effort is supported by the State of Maryland's EARN Initiative – standing for Employment Advancement Right Now – supporting regionally-based, industry cluster-led workforce development projects to address critical skill gaps needed for available jobs. Led by the Anne Arundel Workforce Development Corporation, this two-year \$366,000 grant is focused on developing foundational security skills combined with hands-on experience in an apprenticeship/mentorship process. In doing so, it seeks to break down the initial barriers of entering the cybersecurity field, jump start careers, and close critical skills gaps found in a variety of professional paths in this industry.

Ivy Tech, as one of our nation's leading community college systems, is active in promoting these types of targeted skill development, but the Indiana Office of Defense Development can play a critical role in helping to facilitate increased collaborations at the state's leading defense installations as well as pursuing state and federal resources.

## Conclusion

By addressing the implications of this assessment, Indiana can strengthen its position in retaining and growing its defense installations. In recent years, Indiana's defense installations have proven to be a significant economic asset that has grown from its pre-recession levels and offers high quality jobs, paying an average of just over to \$70,000 compared to the state average private sector industry salary of just \$40,000. More than 10,000 Hoosiers are employed across Department of Defense (DoD) installations and facilities located in Indiana, including major installations found in the communities of Crane, Indianapolis, Butlerville, Edinburgh, Fort Wayne, Peru and Terre Haute.

Given that the U.S. military is among the most technology-sophisticated organizations in our nation, it is critical for efforts to retain and grow its defense installations to create a high value-added, local environment in the specific technology development, deployment, and talent focus areas of its leading military installations. In Indiana these technology focus areas across its leading defense installations, include:

- Electro-Optics, Sensors and Surveillance
- Advanced Electronics
- Chemistry Materials
- Information Technology/Computer Science
- Warfighter Technologies
- Unmanned Aerial Systems.

This assessment contributes to the ongoing work of the Indiana Office of Defense Development (IODD) to strengthen the ties with Indiana's Higher Education institutions to grow the defense sector in Indiana and continue to create high quality jobs for Hoosiers.

## Appendix A Indiana Key Military Installation Sites – Key Informants Interviewed

Name	Title	Installation
Major General Omer C. Tooley	Commander	Camp Atterbury--Muscatatuck Center for Complex Operations
Colonel Richard Shatto	Post Commander	Camp Atterbury
Lt. Colonel Barry Hon	Deputy Commander and Site Manager	Muscatatuck Urban Training Center
Colonel Douglas J. Schwartz	Commander - 434th Air Refueling Wing	Grissom Air Reserve Base
Colonel Donald J. Bonte, Jr.	Commander - 181st Intelligence Wing	Hulman Field
Colonel Patrick R. Renwick	Commander - 122nd Fighter Wing	Fort Wayne International Airport
Brian D. Blackwell	Department Director	Crane Division

## Appendix B Interview Guide to Analyze Defense Technology Assets within the State of Indiana

### Mission and Size

1. What is the principal mission of [*Name of Command*] on [*Name of Base*]?
  - a. How has the principal mission of [*Name of Command*] changed in the last five years?
  - b. How do you expect the principal mission of [*Name of Command*] to change in the next five years?
2. How many employees does [*Name of Command*] have on [*Name of Base*]?
  - a. Has this grown or declined in the last 5 years?
  - b. How do you expect it to grow in the next five years?
3. How many what is the approximate budget of [*Name of Command*] on [*Name of Base*]?
  - a. Has this grown or declined in the last 5 years?
  - b. How do you expect it to grow in the next five years?

### Technology Focus and Needs

1. What are the key technology areas of focus of [*Name of Command*] on [*Name of Base*]?
2. Who are your major collaborators around the nation and in Indiana on these technologies?
  - a. Probe on Technology Alliances, CRADAs, MOUs, other
  - b. Probe on IN interactions, national interactions
3. Are there emerging technology development areas of importance to [*Name of Command*] on [*Name of Base*]?
  - a. What are some of your specific needs related to your planned work in this technology area? (focus on talent, equipment, infrastructure)
  - b. Are you experiencing any barriers in relation to your planned work in this technology area?
4. How do you specifically work with Indiana colleges and universities to meet your research and technology needs?
  - a. Probe on specific interactions?
  - b. Probe on key institution and department level interactions?
  - c. Probe on specific research institutes?
  - d. What could be done to improve these interactions?
5. What are the current or emerging areas of technology development that are well suited for university research partnerships?

**Talent Focus and Needs**

1. What are the key talent requirements overall for [*Name of Command*] on [*Name of Base*]?
  - a. Are their specific skill capabilities that are hard to fill?
  - b. Do you have close recruiting or working relationships with Indiana or national universities to address your talent needs?
    - i. Probe on specific IN interactions
2. Do you have any emerging talent requirements related to changes in mission or technology focus?
  - a. How are you meeting/How do you plan to meet these needs?
3. How do you specifically work with Indiana colleges and universities to meet your talent needs?
  - a. Probe on specific interactions?
  - b. Probe on key institution and department level interactions
  - c. What could be done to improve these interactions?

**Ideas about How to Move Forward**

1. What are some actions that can be taken **on your base** to better meet your current and emerging technology and talent needs?
2. What are some actions that can be taken **by the State of Indiana** to better meet your current and emerging technology and talent needs?
3. What are some actions that can be taken **by Indiana Colleges and Universities** to better meet your current and emerging technology and talent needs?
4. Other issues / suggestions / ideas?