

Accelerating University Talent Development and Research & Development Partnerships at Aberdeen Proving Ground (APG)

*Prepared for Economic Alliance of Greater Baltimore (EAGB)
and Chesapeake Science & Security Corridor (CSSC)*

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Since 1917, the Aberdeen Proving Ground has been a vital contributor to the state and regional economy, and continues to demonstrate its role as a significant strategic asset to our nation. The soldiers trained, the technologies conceived, developed, tested, proven and integrated there are part of the very foundation upon which our nation has been built, protected, and our quality of living improved.

With the implementation of the 2005 BRAC, APG has changed dramatically – much due to its partnership with the community and broader role in the construction and defense of our great nation. As a community we testified on behalf of APG, its mission and its readiness for growth. Today, annual research and development expenditures at Aberdeen Proving Ground exceed \$15 billion. There are currently more than 21,000 people working at APG today as part of more than 90 distinct and dynamic tenant operations.

Given new threats here at home and throughout the world, APG must again have the support of the community to sustain its mission to improve the safety of the warfighter, our national security and our freedoms. The engagement of private industry and the education community is essential to the pursuit and execution of this mission. Going forward, providing the necessary higher education programming to produce the required talent, research and technical advancements will be no less essential.

Austere times require partnership – industry, government and education working together. Experience has proven this collaboration also provides the best means in which to leverage the federal investment, both intellectual and financial, occurring at APG. The objective behind this report is to support APG, expand workforce and talent development efforts, foster creation of new businesses enterprise and the discovery of new cutting edge technologies. Accomplishing this will help drive high-value, knowledge based economic development throughout the Greater Baltimore region and northeast Maryland.

The Economic Alliance of Greater Baltimore is a public-private partnership – leaders from government, industry and higher education working in collaboration for the purpose of promoting regional economic development. We are proud of our collaboration with the Battelle Technology Practice and the Chesapeake Science & Security Corridor (CSSC) in the development of this important study. We look forward to our continued work with our partners in Harford and Cecil Counties and the State of Maryland – as a community in support of the warfighter and the men and women who have made APG the vital technology resource it is today.



J. Thomas Sadowski
President & CEO

Executive Summary

An independent, fact-based assessment of the business case advancing a strong university resource presence in Northeastern Maryland finds a strong value proposition for Aberdeen Proving Ground (APG) organizations and specific opportunities for advancing university collaborations. This is matched by a rich complex of universities within 90 minutes of Aberdeen that align strongly with the technology focus areas and emerging opportunity areas found across APG organizations for which closer proximity can be advanced.

Value of Closer Proximity for Talent Development & Research Collaborations: From a talent perspective, closer proximity of university collaborators can advance much needed master's level education programs that couple teaching basic methods with more hands-on learning and applications development to create more "journeyman" scientists and engineers.

At the same time, closer proximity of university collaborators would offer the opportunity to establish relationships and improve the ability to recruit doctoral students and post-graduate fellows working on APG-related research projects for basic research at APG.

In research, close proximity of university shared use facilities supported by APG organizations would enable a more interactive environment between APG researchers and university researchers to address both thorny multi-disciplinary research challenges and to speed the pace of research advances. So, while not important for improving the quality of university efforts on their own research projects, it would raise the broader level of science and creativity for APG's own research efforts.

Specific Opportunities in Emerging Technology Areas for Proximity-Based APG-University Collaborations: Five specific opportunities for collaboration were identified in critical areas of emerging technology development at APG that call for university-related talent and research collaborations that would benefit from proximity to APG, including:

- System of systems network development that goes to the promise of C4ISR full life cycle development
- Cybersecurity talent connections and applied research collaborations
- Systems biology tying together ongoing efforts in genomics and proteomics
- High performance computing for modeling

- Incubating material sciences solutions

These specific opportunities would each engage multiple organizations at APG and so have critical mass and broad impact. The emphasis in activities between talent development and research collaborations varies among the opportunities as profiled in the text box below.

A Rich Complex of Universities in the Broader Aberdeen Region Exists with a Strong Alignment to Technology Focus Areas and Specific Opportunity Areas for Further Collaboration of Universities with APG. Within a 90-minute drive of Aberdeen Proving Ground are 42 universities in Maryland, Delaware, Pennsylvania and New Jersey conducting research activities and offering bachelor and graduate level degrees in computer sciences, engineering, material sciences and life sciences. According to the National Science Foundation's University Research & Expenditures Survey, these 42 institutions conducted over \$4.8 billion in total research and development, or 8.2 percent of the total U.S. university research expenditures. In just Maryland, there are 12 universities conducting research within 90 minutes of APG, with a combined total research and development spending of \$3 billion in 2010. The closest of which is approximately 60 minutes commuting distance.

A closer examination of talent and research efforts in the technology focus areas found across APG organizations found:

- *The level of talent generated each year by universities within 90 minutes of APG is significant, representing more than 4 percent of all graduates with a bachelor's degree and higher across all the technology focus areas identified at APG and typically above 1,000 graduates annually for each the technology focus areas.*
- *The level of research and development spending in broad fields associated with the technology focus areas found at APG is quite substantial in many of the technology fields, standing at 10 percent or higher of the U.S. total for all universities in sensors, electronics and communications, testing & evaluation and information technology and software development. Medical research is also notable, standing at 8.6 percent of the U.S., represents more than \$900 million in funded research. This broad R&D strength points to the number of top tier research universities within 90 minutes of APG.*
- *In the level of publications activity, the regional universities within 90 minutes of APG are at approximately 5 percent or higher of U.S. publications for all of the technology focus areas found at APG, and also have level of quality as measured by citations per publication, particularly for materials research, pathogen detection and countermeasures and information technology and software development.*

Five Specific Opportunity Areas for Collaboration

■ System of systems network development contributes to C4ISR full life cycle development.

What is it? An emergent class of systems which are built from independent components that in turn are often large scale on their own. Spans physical, information, cognitive and social domains—highly interactive, focus on real time decision-making, mutually interdependent

Why? Integral to network centric warfare—military's equivalent of "Big Data"; Significant cross-cutting needs in talent and applications development

Possible activities: 1) Broader applied education and training of engineers with tailored courses, instructional labs, and master's research projects; and 2) Create a dedicated collaboration space in which best practices with academia and industry on system of systems networks can be shared and new innovation explored

■ Cybersecurity talent connections and applied research collaborations

What is it? Involves both the protection of information and network systems, as well as how to conduct cyberwarfare and attack computer and network systems. The technology focus of cybersecurity at APG goes beyond information assurance of computer systems to include a focus on the device level cybersecurity from radar to sensors to handheld devices that touches upon embedded systems and signal processing algorithms.

Why? Demand for talent pipeline outpaces the supply; Growing demands for improved technologies and practices

Possible activities: 1) Build stronger connections to the talent pipeline being generated through Information Assurance programs found across the region; 2) Augmenting the curriculum to address broader cybersecurity topics that APG addresses; 3) Having Professors of Practice drawn from the ranks of APG to work with students on applied research problems; and 4) Creating more intensive cyber engineering and immersive programs to engage top students.

■ Systems biology tying together ongoing efforts in genomics and proteomics

What is it? Considers the complex interactions within biological systems on how cells function within particular networks such as in cell signaling or metabolic processes that determine the physiological and biochemical properties of cells.

Why? Enhance next generation of detection and countermeasures for chem/bio warfare; Expose APG researchers to cutting edge approaches; Multi-disciplinary nature of systems biology requires a more collaborative approach

Possible activities: 1) Focus on creating collaboration space for wide range of university researchers and doctoral students/post-docs to work in proximity with APG researchers, including possibly joint projects; and 2) Augment existing lab facilities with enhanced modeling and informatics.

■ High performance computing for modeling

What is it? High performance computing has become the critical third leg to scientific research along with theory and experimentation. Focus on computer-based models and numerical analysis techniques to simulate, evaluate and solve research problems.

Why? Strong demand for broader uses of HPC including network centric warfare/cybersecurity, chem/bio pathogen research, and testing and evaluation, among others; Lack of capacity today at APG to support broader applications development and user engagement

Possible activities: 1) Create a dedicated collaboration and user support center for computational sciences analysis, visualization and modeling—example of Pittsburgh Supercomputing Center, but for multi-university presence; and 2) Tap the broad expertise in high performance computing for modeling and applications development found at universities in a more efficient and timely manner

■ Incubating material sciences solutions

What is it? Increased focus on engineering of materials is becoming a more complex effort with rise of multi-functional and advanced composite materials involving a convergence of technologies and more sophisticated trade-offs across key requirements.

Why? Quicken the pace of "lab to solution" cycle from proof of principle to commercializable product; value to have a range of collaborators from university, SBIR and other industry players

Possible activities: 1) Create a Materials Applications Center with flexible lab space and access to existing material sciences facilities at APG; and 2) Consider ways to invite collaborators to Materials Applications Center through open solicitation of best ideas to conduct proof of concept and other development activities

- *Generally Maryland's universities within 90 minutes contribute at 40 percent to 60 percent of the research and talent activity level of all the universities in the broad region within 90 minutes of APG—suggesting the sizable, but not dominant level of activities.* Other universities just outside of Maryland are also an important resource for talent and research collaborations in the technology focus areas found at APG.

Beyond the alignment of regional university talent and scholarly activities in the technology focus areas found at APG, the universities within the broad Aberdeen region also have leading federally funded research centers in the specific opportunity areas of emerging technology development found across the organizations at Aberdeen Proving Ground.

Overall, a key takeaway is that the diversity of technology focus areas at Aberdeen Proving Ground are generally well served by the universities in the broad Aberdeen region in terms of talent and scholarly activity. This suggests that the potential to grow collaborations are in place. The proximity of this rich complex of universities to Aberdeen Proving Ground in concept can have a tangible value for advancing collaborations. By being close to Aberdeen Proving Ground, faculty and their students can more easily engage in on-site activities at APG, including conducting joint research projects and accessing key laboratory facilities. Proximity also enables offering more intensive in-person education and training courses with existing faculty on site at APG. Faculty working in close collaboration with APG organizations can build into their schedules designated days in which they are on site at APG without diminishing their responsibilities at their university campuses. Similarly, students can take on internships and joint research projects without having to necessarily relocate for periods of time.

The challenges to address the missing presence of university resources in the region needed to offer a world-class technology location that fully maximizes the potential of Aberdeen Proving Grounds are substantial, and require broad community engagement and APG involvement.

Universities involved with APG have specific issues holding back their more active presence in the APG community, including:

- Having predictable funding mechanisms for advancing research is critical to engaging universities.
- Top down research relationships alone are not sufficient to drive university collaborations, there needs to be active engagement of APG researchers on the ground.

- There is a strong value proposition between educational courses and research collaborations, but over time educational courses need to be sustainable to advance university engagement.
- A key challenge in educational programming is going beyond individual courses and advancing degree and certificate programs.

What stands out is that there is currently no mechanism found across the organizations at APG to advance collaborative approaches with universities on talent development and R&D to co-locate in Harford County. One suggestion was to create an intermediary entity governed by an APG Science & Technology Council led by representatives drawn from across the APG organizations. The focus of the APG Science & Technology Council would be to facilitate cross-organizational need identification for university-related talent development and research collaborations and possible business models and policies. A university advisory council could work alongside the APG Science & Technology Council and help in refining approaches and policies around identified needs to further engage university partnerships. The universities serving on the advisory council might be drawn from those universities with active CRADA relationships with APG organizations. A full time staff director position would need to be established, possibly as a loaned executive from APG. Administrative support would also be needed, and might possibly be accessed through the Chesapeake Science and Security Corridor.

Best practices also suggest that Harford and Cecil Counties need to play a key role in advancing community efforts to promote more university presence in the region. The community benchmarks of Huntsville, Alabama and Dayton, Ohio demonstrate that community-wide engagement and initiatives can matter significantly in advancing university talent and research collaborations with military research and engineering organizations. These two community benchmarks offer the following insights:

- Leadership is critical for advancing community wide efforts to advance university collaborations with military research and engineering organizations.
- Advancing a lead local university presence is essential and can be done from scratch and in consortiums.
- Having physical, shared use facilities located in the community, including at research parks, offer real value to advancing collaborations.

The opportunity and value of moving forward with accelerating university-related talent and research activities located close to APG are clear as is the potential value of working with the rich complex of universities within the broad Aberdeen region. But a focused

strategy and specific action plan is needed to address the challenges and realize the potential for creating a world class technology hub with a vibrant university presence at APG.

Introduction

The 2005 base relocation and closure (BRAC) decisions have fundamentally transformed Aberdeen Proving Ground (APG) into one of the military's leading and most diverse centers for science and technology development. With BRAC implementation completed, APG is taking its place as a premier site of military research and development, testing and evaluation and acquisition involving a broad range of technology capabilities, including:

- Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance (C4ISR) and Information Systems
- Land Combat Systems
- Chemical and Biological Defense
- Medical Research

"Aberdeen Proving Ground has been, but will be to a greater extent, one of the Army's major hubs of research and development of new technologies, and the testing and evaluation of those new technologies that lead to fielding new systems to support the warfighter."

Comments from Army Col. Andrew Nelson, deputy garrison commander for transformation, "BRAC Transforms Aberdeen Proving Ground Mission," American Forces Press Service, March 7, 2011

The implementation of this transformation of APG to a world class research and development site has already involved more than \$1 billion in infrastructure upgrades and new facilities. But a successful implementation requires more than simply enhanced bricks and mortar at the base.

For Aberdeen Proving Ground (APG) to thrive and be a world-class technology hub also requires the broader community in the APG region to offer a location rich in science and technology resources. Already there has been a substantial increase in leading technology firms in Harford County to serve the enhanced mission found at Aberdeen Proving Ground. The Harford County Office of Economic Development reports that 87 new defense contractors have relocated to the county, bringing the total number of defense contractors to 110. These defense contractors are among the leading technology firms in the world and their growing presence is transforming the local economy around the Aberdeen Proving Ground.

Also needed in the region to maximize its potential as a world-class technology hub is the presence of university resources for access to top scientific and engineering talent development as well as basic research and cutting-edge technology collaborations that align with the varied and extensive research and development activities now found at Aberdeen Proving Ground. While there have been substantial advances in addressing the

STEM education pipeline and the availability of associate and bachelor level technical degrees in Harford and Cecil Counties in recent years, a growing presence of more advanced research university resources has not taken place. This is not a reflection of the lack of university collaborations with military organizations at Aberdeen Proving Ground involved with research and development. Indeed, while difficult to measure in aggregate, there are extensive interactions by military organizations at APG with universities and the top talent they offer from faculty, postdoctoral fellows and graduate students. But by and large, this is an arm's length relationship between universities and military organizations at APG.

Project Purpose, Objectives, Methodology and Consulting Team

The purpose of this report is to provide an independent, fact-based assessment of the business case for advancing a strong university resource presence in the Northeastern Maryland region to serve the broad-based military research and development, testing and evaluation and acquisition mission of Aberdeen Proving Ground. The specific project objectives are to:

- Identify specific opportunities in technology focus areas found across organizations at APG that are well suited to growing an increased university resource presence at APG.
- Benchmark illustrative universities currently meeting the talent and/or R&D needs of APG as well as examples of how other military bases with a strong research and development, testing and evaluation and acquisition mission have grown their community to support university-related collaborations.
- Assess the capabilities and alignment of Maryland universities and colleges to meeting the opportunities and needs, as well as other leading research universities in surrounding jurisdictions.
- Set out the business case with identified strategic opportunities for collaboration that will inform specific program development activities.

Science, Technology, Engineering and Math (STEM) Education Initiatives Underway In Harford and Cecil Counties

Harford and Cecil County have very active initiatives for K-12 STEM education. The Northeast Maryland Technology Council (NMTC) sponsors STEM nights for middle school students to peak their interest in STEM fields. NMTC also sponsors Science Café's with local scientists providing brief talks on their research to the general public and science curriculum kits in local libraries. The school systems in Harford and Cecil have incorporated elements of STEM education into their standard curriculum. Both Counties' have also augmented their standard curriculum with specialized programs at the elementary middle and high school levels.

■ HARFORD COUNTY:

- *Engineering is Elementary* is in all elementary schools, grades one through five. This blended STEM curriculum reaches every student, every year during science instruction. Over 650 elementary teachers have received professional development to support the implementation of this curriculum.
- *Project Lead the Way: Gateway to Technology* was introduced at Southampton and Havre de Grace Middle Schools. This year Edgewood Middle school will offer Project Lead the Way and C. Milton Wright and Aberdeen High Schools will offer *Project Lead the Way: Pathway to Engineering*.
- *Science and Math Academy (SMA)* is a four year program magnet high school program with a mandatory capstone research project, which is to be completed during the senior school year. It accepts approximately 53 freshmen each year. The SMA offers young scholars challenging coursework which integrates science, technology, engineering, and mathematics and emphasizes research and real-world application.
- *Bio-Medical Science Program*, is currently at Bel Air High School and expanding to Havre de Grace next year. The Biomedical Sciences program is nationally certified by STEM curriculum provider Project Lead the Way (PLTW). The program offers students an array of advantages, from career readiness and hands-on experience to college preparatory-level classes, labs, and creative exercises.
- Plans are underway for a Cybersecurity program launching at Harford Technical High School.
- A STEM Teacher Academy was created in 2010 providing college level training in the core sciences for thirty two teachers, grades 3 through 8. Partners include Frostburg State University, Morgan State University, Towson University and UMBC.
- National Math and Science Initiative (NMSI) partnership with Boeing and Department of Defense for Aberdeen High School and Havre de Grace High School to encourage Advance Placement class participation in Math and Science.
- Partnerships with community organizations resulting in events such as STEM Nights and teacher professional development.

■ CECIL COUNTY

- Kindergarten engineering program is provided in all 17 elementary schools.
- After-school STEM Club provided in 6 middle schools.
- STEM and Beyond Nights, 2 middle and 6–8 elementary schools per year.
- CERDEC is providing hands-on STEM activities at every elementary school over the next 4 years. The CERDEC team spends a week at each school so every child K-5 has an opportunity to experience the hands-on learning activity.
- Developing the "Cecil STEM Society" for students K-12. ATK is spearheading this new initiative modeled after the Harford Senior Society.
- Engineering is Elementary is starting this year in grades 3–5
- STEM Summer Camps: 9th grade career exploration and incoming 6th grade RTTT STEM Summer Academies; incoming 7th grade RTTT STEM Summer Academies.
- Middle school mathematics remediation through DimensionU. Cecil County Public Schools is the first school district in Maryland to receive the math learning tool "DimensionM" through the educational outreach efforts of the U.S. Army Edgewood Chemical Biological Center (ECBC)—sponsored by the National Defense Education Program (NDEP). Looking to help local teachers enhance STEM components in their middle school curriculum, ECBC provided Cecil County Public Schools a package that included DimensionM licenses and a three-day professional development training for 23 of their middle school math teachers.
- Teacher training academies and module trainings on SPORTS MATERIALS

The methodology for addressing these objectives is set out in Figure 1 below. The starting point of the project is the assessment of APG talent and research requirements. This assessment provides an integrated technology framework across the organizations resident at APG. The mere number of organizations found at APG is considerable—more than 90 in all. So, having an integrated technology framework allows one to go beyond individual organizations to viewing the collective focus of technology activities at APG.

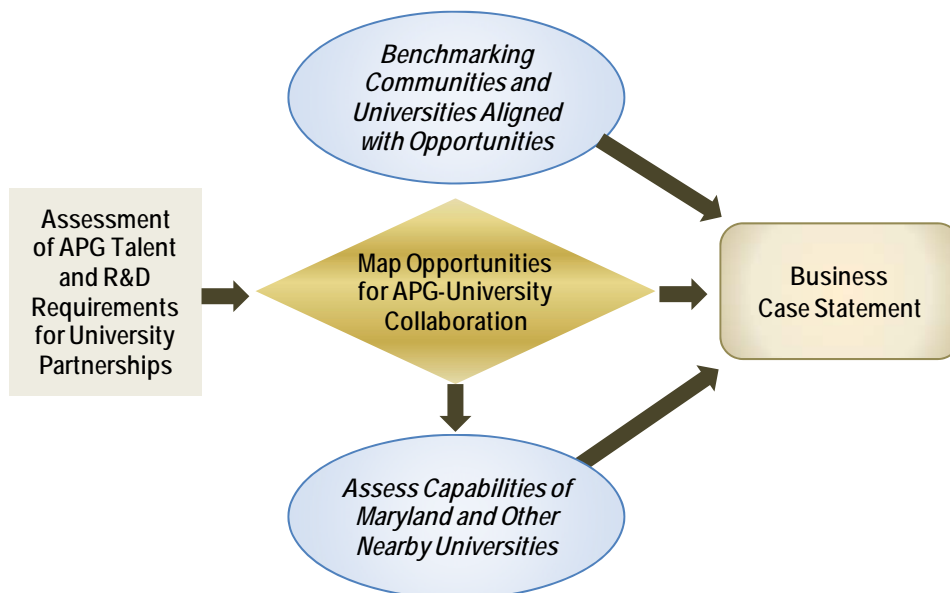
This assessment of APG talent and research capabilities sets the focus of the analysis to map specific opportunities for collaboration between universities and APG organizations. This mapping was informed by discussions with senior leadership at the major research and engineering organizations at APG.

Based on this assessment of APG and mapping of opportunities related to APG talent and research requirements, it is possible to then assess the capabilities of universities in Maryland and others nearby to APG in terms of talent generation and research capabilities.

The benchmarking analysis, meanwhile, examines what it takes to realize the potential for collaboration with universities considering what drives specific university engagements and what will add value and advance broader community-wide involvement to bring university collaboration forward.

The business case statement brings together the requirements by APG for university-related talent and research collaborations with the alignment of universities in the broad Aberdeen region and considers the challenges and opportunities in light of best practices.

Figure 1: Graphic Depiction of Project Objectives and Approach



The Economic Alliance of Greater Baltimore (EAGB), in concert with the Chesapeake Science & Security Corridor(CSSC), retained the services of the Battelle Technology Partnership Practice. The Technology Partnership Practice (TPP) is the technology-based economic development consulting arm of Battelle, the world's largest independent non-profit research and development organization. Battelle created the Technology Partnership Practice back 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 Maryland and brings a strong familiarity and knowledge of Maryland's diverse set of universities, industry drivers, and federal government complex and key government agencies.

Assessment of Aberdeen Proving Ground Talent and Research Requirements Relating to University Collaborations

The opportunities for enhancing the presence of university activities in the Northeastern Maryland region associated with Aberdeen Proving Ground must be centered upon the specific needs and requirements found across the organizations at APG. The 2005 BRAC built upon APG's longstanding missions in the research, development and testing of land combat systems and chemical and biological defense, by:

- Adding communications, electronics and computer security research and development with the relocation of the Army's C4ISR (command, control, communication, computers, intelligence, surveillance & reconnaissance) center of excellence.
- Enhancing chemical and biological research and development with the relocation of the Army's activities involved in Medical Research Institute of Chemical Defense (MRICD), the Joint Program Executive Office for Chemical and Biological Defense, Non-Medical Chemical and Biological Defense Development & Acquisition and the Defense Threat Reduction Agency.
- Expanding the existing base of testing and evaluation with the relocation of the Army Test and Evaluation Command (ATEC).
- Adding a lead research institute for training, leader development, soldier research and development involved with behavioral and social science research involving survey research on soldier and leader attitudes and occupational analysis.
- Adding Army Research Laboratory's Vehicle Technology Directorate focused on pursuing mobility-related science and technologies leading to advanced capabilities and improved reliability for Army air and ground vehicles involving platform, propulsion, intelligent systems and logistics technologies.

The result is that Aberdeen Proving Ground is now home to 11 major commands and supports more than 80 tenants, 20 satellite and 17 private activities that drives the employment of more than 21,000 military, civilian and contractor employees. So, the breadth of organizations involved in military research and development, testing and evaluation and acquisition is quite extensive at APG.

To identify opportunities for enhancing university partnerships, it is important to translate the extensive organizational presence of Army activity at Aberdeen Proving Ground into specific areas of technology focus that can be aligned with university activities. As a starting point, Battelle worked in consultation with senior staff at APG as well as contractors to create an integrated technology framework across the breadth of organizations found at APG. The initial drafting of this integrated framework was developed by pulling together information from a wide variety of public information sources, including:

- Web sites of the various commands at APG
- Review of previously completed studies conducted by CSSC and the State of Maryland
- Information compiled by the Army Alliance's report "Aberdeen Proving Ground: Technology for the 21st Century"
- Available information on grant awards and solicitations, including broad agency announcements, federal Small Business Innovation Research grant awards, Multi-Disciplinary University Research Institutes, Collaborative Technology Alliance grants and other grant mechanisms

In these efforts, Battelle tried to identify the availability of more comprehensive databases of education and training activities and research grants with universities undertaken by the organizations at APG. As might be expected given the diversity and number of organizations, none exist today, so seeking to aggregate the complete footprint of technology-related activities being undertaken at APG remains somewhat "hit or miss."

With these caveats, Battelle identified five specific technology focus areas that help in understanding the research and development activities across the organizations at APG, including:

- Sensors, Electronics and Communications
- Information Technology and Software Development
- Materials Research
- Pathogen Detection and Countermeasures
- Testing & Evaluation

Below is a profile for each of these technology focus areas, including the specific range of capabilities, further insights from interviews with senior level APG officials as well as contractors, examples of activities from grant awards and solicitations and likely talent degree requirements.

■ SENSORS, COMMUNICATIONS AND ELECTRONICS

SPECIFIC TECHNOLOGY CAPABILITIES

- Radio Frequency Technology
- Antenna Technology
- Power Components and Sources
- Optoelectronics and photonics
- Signal Processing (analog and digital)
- Wireless Sensor Networks
- Sensor data integration

INSIGHTS FROM INTERVIEWS

- Systems on a chip involving multi-sensors is a key focus of research and development
- Strong focus on engineering solutions including production engineering manufacturing support
- Strong emphasis on airborne intelligence, surveillance and reconnaissance

EXAMPLES FROM GRANT SOLICITATIONS AND AWARDS

Opportunistic Sensing for Object and Activity Recognition from Multi-Modal, Multi-Platform Data; Battlefield sensors; Body wearable radio direction finding antenna; Urban & Indoor Position & Orientation for Small Platforms; Wide-Area Structure and Infrastructure Mapping; Ground Penetrating Radar; Airborne Electro-optic/Infrared (EO/IR) Persistent Surveillance; Aided/Automatic Target Recognition (AT); Cognitive Radio and Cognitive NetOps; Low Cost On-the-Move (OTM) SATCOM Antennas; Rechargeable Batteries

TALENT REQUIREMENTS

- Systems Engineering
- Electrical Engineering
- Computer Engineering
- Chemical Engineering

■ INFORMATION TECHNOLOGY AND SOFTWARE DEVELOPMENT

SPECIFIC TECHNOLOGY CAPABILITIES

- Cybersecurity—information assurance, malware detection, intrusion detection
- Information Fusion
- Network Sciences (network theory, network modeling and simulation)
- High Performance Computing
- Software Engineering

INSIGHTS FROM INTERVIEWS

- Information assurance must go beyond simply computer science approach to include device-orientation and protection at the electronics and embedded systems level
- Cybersecurity not just protection of systems but also more offensive focus on how to attack networks
- Software becoming more pervasive in military operations, but typically acquires more commercial-off-the shelf applications and focus is on integration and support, including information assurance. Approach is no enhancements beyond 25% of the system.

- Significant high performance computer at APG that continues to be upgraded, but requires tools and portals for greater usage

EXAMPLES FROM GRANT SOLICITATIONS AND AWARDS

SOA Software Technologies for Planning, Execution, and Monitoring of Full Spectrum Military Operations; Cyber Awareness Framework for Attack Analysis, Prediction, and Visualization; Unified Research on Network-Based Hard/Soft Information Fusion; Characterizing the Interdependencies Among Military Network Components; Adversary Social Networks; Ontology and Shared Metrics for Dynamic Composite Networks; Opportunistic Sensing for Object and Activity Recognition from Multi-Modal, Multi-Platform Data; Tools for the Analysis and Design of Complex Multi-scale Networks; Distributed and Real-time Data Fusion and Information Extraction; Computer-aided Human Centric Cyber Situation Awareness

TALENT REQUIREMENTS

- Information Technology
- Software Engineering
- Computer Science
- Information Assurance

■ MATERIALS RESEARCH

SPECIFIC TECHNOLOGY CAPABILITIES

- Wide range of materials—metals, polymers, ceramics, composites
- Energetic materials
- Multi-functional materials
- Breadth of functional expertise from materials synthesis to characterization to modeling to scale-up processing

INSIGHTS FROM INTERVIEWS

- Traditionally very metals-based for armor materials, but getting strong in polymers and composites
- Multi-functional materials are a key area of development → integrate composite with a material that generates energy
- Growing need for multi-scale model system that will predict lifetime of materials in actual structures
- Strong focus on materials-by-design approach involving relationship of structure, processing and properties, informed through use of computational modeling

EXAMPLES FROM GRANT SOLICITATIONS AND AWARDS

Alloy development for lightweight armor materials; Optimal response to ballistic impact on ceramic materials; Structural composites for armor applications; Affordable precision munitions, projectiles and multifunctional warheads; Multiscale reactive modeling of insensitive munitions; Reconfigurable Matter from Programmable Colloids; Atomtronics: Material and Device Physics of Quantum Gases; Fundamental Study of Defects and Their Reduction in Type-II Superlattice Materials; Multiscale Design and Manufacturing of Hybrid DWCNT-Polymer Fibers; Transformation Optical Metamaterials

TALENT REQUIREMENTS

- Materials Science Engineering
- Chemical Engineering
- Polymer Sciences
- Systems Engineering

■ PATHOGEN DETECTION AND COUNTERMEASURES

SPECIFIC TECHNOLOGY CAPABILITIES

- Chemical agent pharmacology & toxicology
- Inhalation toxicology
- Chemical and biological sensing using spectroscopy with advanced algorithms
- Aerosol physics
- Genomics & proteomics
- Virology and immunology
- Mechanisms of action of action of chemical and biological agents through molecular analysis and in vitro models
- Development of pharmaceutical agents

INSIGHTS FROM INTERVIEWS

- Highly mature in chemistry based analysis
- Recent development of genomics and proteomics, for detection of biological agents. Involves gene sequencing and mass spectroscopy
- Detection involves development of innovative devices involving sensing, communication, information processing—many of the same technology integration found in C4ISR
- Recent advances in analysis of trace amounts of explosives and connecting to fingerprints using Raman Chemical Spectroscopy
- Not a lot of use of high performance computing and computational analysis yet—needs to come with advancement of systems biology approaches
- Nextgen Information assurance must go beyond simply computer science approach to include device-orientation and protection at the electronics and embedded systems level
- Considerable in-house development of pharmaceutical countermeasures—from basic research into translational sciences (pre-clinical)

EXAMPLES FROM GRANT SOLICITATIONS AND AWARDS

Mechanism of Bacterial Spore Germination and its Heterogeneity; Catalytic Bioscavenger Medical Defense Research; Engineering of Paraononases for Pre- and Post-Treatment of Intoxification; Engineering PON1 and OPH for Altered Substrate Specificity and Improved Properties (NIH); Enhancement of Organophosphinate Hydrolase Activity Through Mechanistic Evaluation; Exploration of the Compatibility of Catalytic Bioscavengers with Conventional Therapy; Molecular Evolution of Human Butyrylcholinesterase for Nerve Agent Detoxification; Molecular Evolution of Human PON to Design Enhanced Catalytic Efficiency for HYDR; Nerve Agent Testing; Organophosphorous Testing; Protein Production Core; Rapid and Large Scale Plant- Based Production of Catalytic Nerve Agent Bioscavenger; Rational Design of Human Paraoxonase to Design Enhanced Catalytic Efficiency; The Expression of Human Catalytic Proteins in Micro Algae on a Commercial Scale; Palm-Sized Automated Chemical Agent Detector: Simultaneous Detection of Biological Agents by Solid-state Hybridization and Naked Eye Visualization; Detecting Bacteria by Direct Counting of Structural Protein Units or Pili by Integrated Virus Detection System and Mass Spectrometry; Multiplex Field Device to Detect and Identify a Variety of Microbial Agents Simultaneously; ECBC Integrated Virus Detection System Technology; Microbial Detection and Identification by Using Mass Spectrometry Data for Diagnostic Purposes; Integrated chemical/biological point detection; Fully automated biological identification; Water/food contaminant detection; Reagent development; Joint Biological Standoff Detection System Blk I; Joint Biological Standoff Detection System Blk II; Joint Service Agent Water Monitor; Chemical Biological Mass Spectrometer Blk III; Wide Spectrometry; Hyperspectral Imaging; Integrated Detection

TALENT REQUIREMENTS

- Toxicology/Pharmacology
- Analytical Chemistry
- Genomics/Proteomics
- Biochemistry
- Virology/Immunology
- Systems Biology

■ TESTING, EVALUATION & LIFE CYCLE ANALYSIS

SPECIFIC TECHNOLOGY CAPABILITIES

- Test and evaluation methodology
 - Program management
 - Modeling and simulation
 - Life cycle statistical analysis
-

INSIGHTS FROM INTERVIEWS

- Traditional focus of testing and evaluation has been on land combat systems—with presence of signature testing facilities such as road way simulator, outdoor test arena for vehicles, armor & ballistics
 - Driving strategically to use more modeling and simulation...with considerable in-house tools development
 - R&D areas of focus in testing and evaluation include analysis of alternatives; technology insertion; future systems development & design
-

EXAMPLES FROM GRANT SOLICITATIONS AND AWARDS

Not an area of research and development solicitation—APG serves as the lead test center for automotive/tracked and wheeled, engineering equipment, direct-fire systems, shoulder-fired weapons, small arms systems, direct-fire weapons performance, emissions characterization, soldier systems, nonlethal weapons, unmanned ground vehicles, transportability, environmental mitigation technologies, vulnerability/lethality, and littoral warfare.

TALENT REQUIREMENTS

- Mechanical Engineering
- Civil Engineering
- Electrical Engineering
- Computer Engineering

Opportunities for Enhancing the Presence of University-Related Talent and R&D Collaborations

To move from technology focus area to specific opportunities for enhancing the presence of university-related talent development and research collaborations, Battelle conducted focused discussions with senior leadership at the leading organizations involved in more intensive research, development, testing and evaluation (RDTE) activities at APG, including:

- U.S. Army Communications and Electronics Command (CECOM), including the Software Engineering Center
- U.S. Army Research, Development and Engineering Command (RDECOM) Human Capital Planning and Development
- U.S. Army Communications Electronics Research, Development and Engineering Center (CERDEC)
- U.S. Army Research Lab, including the Computational and Information Sciences Directorate, the Survivability and Lethality Analysis Director and the Weapons and Materials Research Directorate
- U.S. Army Edgewood Chemical Biological Center
- U.S. Army Test and Evaluation Command (ATEC)

A full listing of those senior staff interviewed is found in Appendix A.

The insights gained from these discussions fall into two categories:

- The value of having closer proximity between APG organizations and their university collaborators
- Specific areas of opportunity in emerging technology focus areas that are well suited to advance more intensive talent development and R&D collaborations in proximity with APG

Value of University Resource in Proximity to APG

In the discussions with senior staff at APG, Battelle also sought to learn more about the existing nature of university partnerships, their effectiveness and the value of having closer proximity to Aberdeen Proving Ground.

On the issue of talent development, the importance of close proximity of more master's level education resources along with greater ability to advance interactions with doctoral level students and postdoctoral fellows was widely noted.

Master's level education resources stands out for many organizations at APG because a large element of the work being undertaken at APG involves more application and engineering-related development and validation than basic research or technology concept formulation. A common hiring practice is to bring on well-qualified, recent bachelor's degree graduates with the expectation that they will pursue their master's degree while working at APG. A key issue regarding master's level education was that it needed to go beyond simply book learning. What is missing in many distance learning approaches is the hands-on learning and application needed for advanced skills development. A key interest raised by several of the senior staff interviewed is having applied master's level programs available that couples teaching basic methods with research projects involving topics relevant to the organizations at APG. One senior staff person referred to this as creating "journeyman" scientists and engineers.

For those who are more involved in basic research and technology concept formulation requiring doctoral level skills, a common need for university relationships was for their talent pipeline. Simply working at arm's length with universities, however, is not viewed as sufficient to attract these doctoral students to join APG. The best success in actually recruiting these doctoral level students upon graduation depends upon having them work closely with APG as students and exposing them not only to the challenging problems that APG organizations address, but the access to scientific collaborators that APG can offer. Still, bringing doctoral and post-doctoral fellows into existing APG facilities may prove difficult to manage on a significant scale so alternative approaches for creating that proximity need to be explored, and might be addressed by having them co-located at university sites for advanced applications development used in master's level education programs or at other designated collaboration research centers. This might also enable the greater use of summer or short-term research project activities with doctoral students as well as sponsoring post-doctoral fellows at APG.

Therefore, proximity of more universities matters in both the development of engineering and science talent with advanced application skills and the recruitment of doctoral-level basic research talent.

In university research and development activities, the value of proximity identified by senior staff at APG did not have to do with its importance in improving the quality of the university research project, but in raising the broader level of science and creativity found at APG. As one senior staff person, who oversees many university research grants noted, the quality of faculty research conducted at their home campuses is top rate and does not hinder the transferability of those results to the Army—so this person did not see a need for proximity between university research and APG. While not disputing this point, many others saw missed opportunities in not having more close proximity for APG.

Of particular concern was the need by APG researchers for more collaboration with university faculty than is generated by stand-alone university projects. The increasingly multi-disciplinary nature and integrated systems approaches of science demand a more interactive environment for carrying out APG research in which university collaborators can work on defined short term projects in conjunction with their graduate and post-doctoral students as well as APG researchers. In addition, there needs to be a place to incubate new ideas and test out applications that bring together a more collaborative approach among university faculty, SBIR companies, prime contractors and APG researchers in focused short-term engagements.

This same view towards increasing collaboration also led one senior staff person to raise concerns that many of the university research awards call for the development of unique facilities, which currently reside at the university for their research purposes and so out of reach to APG researchers. Instead, if these unique, often signature, facilities could be co-located at APG they would become transformed into a more highly valued, shared use facility.

By advancing this concept of collaboration and co-location facilities, not only will APG harness more value from university research grants, it will transform them into more active collaborations and meet the need for closer working relationships with doctoral students and post-doctoral fellows.

There is currently no mechanism found across the organizations at APG to advance these collaborative approaches with universities on talent development and R&D. One suggestion was to create an intermediary entity governed by an APG Science & Technology Council led by representatives drawn from across the APG organizations. The focus of the APG Science & Technology Council would be to facilitate cross-organizational need identification for university-related talent development and research collaborations and possible business models and policies. A university advisory council would work alongside the APG Science & Technology Council and help in refining approaches and policies around identified needs to further engage university partnerships. The universities

servicing on the advisory council might be drawn from those universities with active CRADA relationships with APG organizations. A full time staff director position would need to be established, possibly as a loaned executive from APG. Administrative support would also be needed, and might possibly be accessed through the Chesapeake Science and Security Corridor.

Specific Opportunities Across Technology Focus Areas Best Suited for Proximity to Aberdeen Proving Ground

To identify opportunities that build upon the value of proximity noted above, Battelle explored in the discussions with senior staff what are the critical areas of emerging technology development and the associated implications for addressing skill capabilities and talent requirements as well as broader research collaborations with universities.

The intent of Battelle was to identify cross-cutting opportunities that would engage multiple organizations at APG in order to have critical mass and broad impact. What Battelle learned was that each organization at Aberdeen Proving Ground pursues its university collaborations and talent development largely in isolation of other organizations. This reflects in large part the focus each organization brings to its specific mission, but it misses opportunities where synergy is not only possible, but strategically important.

In pursuing the identification of specific opportunities it was not possible for Battelle to conduct a comprehensive independent scan across the talent and university research activities underway at all of the organizations at APG. This is due to the fact that there are no comprehensive databases of training and education efforts underway across the organizations at APG, nor is there a single database of university research grants and collaborations across organizations at APG. This lack of comprehensive databases on university relationships for talent development and research illustrates the extent in which each organization at APG goes about developing its own relationships with universities and the lack of coordination and collaboration across APG organizations.

Battelle's identification of opportunity areas was largely informed through the discussions with senior APG staff. This suggests that additional opportunity areas may exist, but require further outreach and discussion to identify. The opportunity areas reflect emerging areas of development that call for university-related talent and research collaborations that would benefit from proximity to APG. The emphasis between talent development and research collaborations varies among the opportunities.

These include:

- System of systems network development that goes to the promise of C4ISR full life cycle development
- Cybersecurity talent connections and applied research collaborations
- Systems biology tying together ongoing efforts in genomics and proteomics
- High performance computing for modeling
- Incubating material sciences solutions

System of Systems Network Development and Engineering

System of systems networking is an emergent class of systems which are built from independent components that are often large scale systems in their own right. These systems of systems frequently span the physical, information, cognitive and social domains, and are interactive and mutually interdependent.

For the military, system of systems networks are integral to the concept of network centric warfare that drives the focus on command, control, communication, computers, intelligence, surveillance & reconnaissance found at APG. Gary Blohm, a former Director at CERDEC, explains it as “... the big network ... how everything ties to that from the sensor to the transport communications, as well as the applications and data fusion.”¹

According to the National Research Council, “the Army’s vision of a network centric capable force is for one that is robustly networked by means of a communications and information infrastructure that is global, secure, real-time, reliable, Internet-based and user driven”.² But the complexity of network-centric operations is significant. Networks are built on top of one another. Social networks [such as those for command and control in the military] are built on information networks, which in turn are built on communication networks that operate using physical networks for connectivity.³

The science and engineering approaches for advancing system of systems is still in its early stages of maturity. There are still significant advances needed in the fundamental knowledge of predicting the properties of large scale, system of systems networks and how they can be best designed for performance even as the demand for engineered

¹ Barry Rosenberg, “CERDEC Director Shares Vision for C4ISR Innovations,” Defense Systems, April 21, 2010.

² National Research Council, “Strategy for an Army Center for Network, Science, Technology and Experimentation, 2007, page 18

³ See National Research Council, Network Science, Prepared by the Committee on Network Science for Future Army Applications, 2006, page 3

solutions and applications for network centric operations in the military are put into practice.

In this unfolding real-world development of network centric operations, Battelle heard consistently across senior APG staff from different organizations, who together represent the full life cycle of network centric operations development, that there were cross-cutting needs among organizations at APG for closer collaborations with universities in system of systems networks.

The most critical need expressed was in broader education and training for engineers involved in system of systems networks. Of immediate concern was the availability of not only basic courses, but hands-on learning and application development close to APG. Several of the senior staff noted the approach of the Naval Postgraduate School located in Monterey, California in its master's level systems engineering program. It offers access to advanced application laboratories for instruction and emphasizes its research programs tapping the combined expertise of faculty and students. It also tailors its courses to be able to address classified materials and topics.

On a broader, more continued education basis, the importance of having a dedicated collaboration space in which best practices with academia and industry on system of systems networks can be shared and new innovations explored was noted. This is very much in line with the recommendation by the National Research Council in its report on "Strategy for an Army Center for Network Science, Technology and Experimentation," that state-of-the-art collaboration facilities are needed that offer smart rooms such as those present at the MIT Media Lab in which the development of new theories, models and technologies are considered that will foster innovation and network thinking. This collaboration center would need to offer an infrastructure capable of hosting new information technologies, such as in physical networks, mobile networked sensors and command and control, which are designed around a controlled environment with human subjects as participants.⁴

This collaboration center should also have a strong tie-in with the extensive research into network sciences that the Army Research Lab (ARL) is undertaking. This includes multi-university teams, in collaboration with industry leaders, working in research centers supported by ARL, including information networks, communications networks, social-cognitive networks and interdisciplinary research. There is truly a national scope to the universities involved with these network science research centers, including Penn State, University of Illinois- Urbana Champaign, Rensselaer Polytechnic Institute, UC-Riverside,

⁴ National Research Council, "Strategy for an Army Center for Network, Science, Technology and Experimentation, 2007, page 40.

CUNY, University of Delaware, USC, UC-Santa Barbara, Northeastern University, UC-Davis, and UC-Santa Cruz. While the basic research into network sciences may continue to be done across the campuses of leading universities involved with the ARL, the collaboration space would allow for university faculty to present their research in a hands-on manner and offer ways to consider how it can be applied including undertaking pilot projects with graduate students and APG scientists and engineers.

Cybersecurity talent connections and applied research collaborations

One of the broadest and most critical talent and applied research collaboration areas of need at APG is in cybersecurity. It is broad for two reasons. First, APG's technology focus on cybersecurity goes beyond information assurance of computer systems to include a focus on the device level cybersecurity from radar to sensors to handheld devices that touches upon embedded systems and signal processing algorithms. Second, APG's mission focus is not simply the protection of information and network systems, but also includes cyberwarfare and how to attack computer and network systems.

Cybersecurity is also one of the most challenging talent pipeline issues facing APG. The reason is simple—demand for cybersecurity trained professionals well exceeds supply nationally. “Desperately seeking cybersecurity pros,” is how an October 26, 2012 article in the federal technology market newsletter, FCW, portrays the challenge. Reporting on a recent cybersecurity panel discussion at the Center for Strategic and International Studies, the senior military adviser for cybersecurity to the Under Secretary of Defense, Army Major General John Davis, noted: “The gap between supply and demand has deep roots ... We don't have the capacity and the right set of skills that we need to do all that's required.”⁵ This skills gap is found across the public and private sectors. NetworkWorld's headline explains in “Hottest IT Skill? Cybersecurity,” U.S. corporations are ramping up their hiring of cybersecurity experts...spanning all industries.” According to the article, “Several trends are driving the demand for cybersecurity experts. Companies have increasingly complex networks, more transactions to process and more data than ever. They're using cloud applications that extend their need for information security outside the perimeter of their networks. Additionally, they're dealing with a flood of user-owned mobile devices such as smartphones and tablets.”⁶ In April 2012 alone, Network World reports, that the number of job openings on Dice.com's web site for IT professionals rose by 74 percent from a year ago with 920 open job listings.

From the breadth of cybersecurity programs underway at universities and community colleges in the broad Aberdeen region, APG appears well positioned to tackle this

⁵ Amber Corrin, “Desperately Seeking Cybersecurity Pros,” FCW, October 26, 2012

⁶ Carolyn Duffy Marsan, “Hottest IT Skill? Cybersecurity,” Network World, May 3, 2012

problem. There are 11 universities within 90 minute drive to APG that are designated as Centers of Academic Excellence in Information Assurance Education by the National Security Agency and the Department of Homeland Security, plus another 6 community colleges, including Harford Community College, are designed as Centers of Excellence in 2 Year Information Assurance Education.

Most recently, the University of Delaware has teamed with Harford Community College (HCC) and Delaware Technical and Community College (DTCC) for a National Science Foundation funded “Regional Cybersecurity Education Initiative” that expands cybersecurity courses and establishes a minor in cybersecurity at the University of Delaware as well as advances a new 2+2 Program to allow community college graduates in cybersecurity from HCC and DTCC to transfer to the University of Delaware to complete a bachelor’s degree in computer and information sciences or computer engineering.

There is an opportunity for APG to build stronger connections to the talent pipeline being generated through Information Assurance programs found across the region. This can include augmenting the curriculum to address broader cybersecurity topics that APG addresses, having Professors of Practice drawn from the ranks of APG to work with students on applied research problems, and creating more intensive cyber engineering and immersive programs to engage top students.

One idea is for APG to mimic the approaches taken by companies like JP Morgan Chase, which has partnered with a number of universities, including University of Delaware, to establish a strategic collaboration involving an Innovation or Technology Center staffed by JP Morgan Chase which conducts applied research with faculty as well as supports a Global Enterprise Technology program designed to provide courses about large-scale information systems across various industries while involving students in either a yearlong consulting project or an extended paid internship during the school year, with close mentoring from JP Morgan staff located at the Innovation Center or its technology partners.⁷ A similar type effort was undertaken by GE with the University of Connecticut School of Business over an 11 year period, in a program known as EDGELab, to provide a hands-on experiential learning accelerator that was highly successful in teaming faculty, students and GE managers to work together on GE strategic IT-related projects. In 2007, it was designated an Honors Program by Computer World.⁸

Another example for more high-end technical cyber talent development is to advance a program similar to what the Air Force Research Laboratory’s Information Directorate in Rome, New York has done with Syracuse University to offer a Cyber Engineering Semester

⁷ See <http://www.udel.edu/udaily/2012/oct/innovation101711.html>

⁸ See <http://www.cwhonors.org/viewCaseStudy.asp?NominationID=193>

for top students. It is an 18-credit undergraduate course of study offering a technically and mathematically rigorous program, similar to a semester abroad in that it fully immerses the students participating into cybersecurity topics and culture. Across the five courses offered, students are introduced to the fundamentals of computer architecture, with an emphasis on security measures; learn about major subsystems and concepts of operating systems and networks; and learn about theory, practice and tools for building highly assured systems. They are also taught to design and implement hardware to preserve the confidentiality and integrity of data and hone their skills through technical discussion, problem solving, writing and public speaking. In addition to the five courses, the students are engaged in an internship at AFRL at the end of the program.⁹

Advancing Systems Biology To Build Upon Recent Efforts in Genomics and Proteomics at Edgewood Chemical Biological Center and Other Growing Medical Activities at APG

Edgewood Chemical Biological Center (ECBC) stands out within the complex of organizations found at APG in being organized for full lifecycle support from research to engineering solutions to testing and evaluation within a single organization. This enables ECBC to seamlessly translate its research into serving its mission of addressing chemical and biological vulnerabilities.

In recent years, the Edgewood Chemical Biological Center has made significant strides in integrating the tools and capacities of genomics and proteomics into its core mission. Through the Genomic Sequencing Center, ECBC is using genomic sequencing to rapidly detect and characterize pathogens. It also performs in vitro cytotoxicity tests on human and animal cells and recently added the capacity to use gene arrays to study the effects of systematic exposures on gene expression. ECBC has also been advancing proteomics to identify biomarkers, which can be targeted for new medical therapeutics to counter toxicological or chemical events. An important capacity found at ECBC is in bio-scale-up processing for producing proteins, enzymes, antibodies and other cell-based products. Another critical capacity at ECBC is its Biosafety Level 3 Laboratory that allows for analysis and testing of highly pathogenic bacterial, viral and fungal micro-organisms.

The efforts of ECBC in the biological sciences has involved extensive collaboration with university researchers, but nearly all of these are at arm's length. In detection and characterization of pathogens, among other universities, ECBC has collaborated extensively with Columbia University's Center for Infection and Immunity, which is internationally known for its efforts to develop and validate techniques for the rapid

⁹ See <http://www.syr.edu/news/articles/2011/cyber-engineering-12-11.html>

identification of pathogens as a means to manage potential threats before they can affect the health of communities worldwide.

Looking to the future, the next generation of ECBC's biological development will involve systems biology, which considers the complex interactions within biological systems on how cells function within particular networks such as in cell signaling or metabolic processes that determine the physiological and biochemical properties of cells. Core to systems biology is a focused approach to modeling biological systems. This in turn requires understanding of biology as an information science that needs to be understood holistically and requires use of emerging technologies to measure biological activities and new analytical mathematical and computational tools.

ECBC is already putting in place many university partnerships around systems biology. But given its inter-disciplinary nature, a more collaborative approach is called for to fully advance the science and exploit the insights from systems biology for addressing chemical and biological vulnerabilities.

Other organizations at APG also may have an interest in considering systems biology approaches. One in particular is the United States Army Medical Research Institute of Chemical Defense (USAMRICD) which focuses in the area of medical chemical countermeasures research and development. Even other organizations at APG whose missions are not primarily involved in medical research have interests that connect to biomedical research that systems biology can inform. For instance, for ARL's Weapons and Materials Research Directorate (WMRD) there is a growing focus on the connection between biology and ballistics in considering the impacts from blunt trauma and brain injury. Systems biology linked with genomics and proteomics may be able to elucidate the cellular processes involved and the key mechanisms at work.

An opportunity to consider for systems biology, as well as the continuing advance of genomics and proteomics, is creating a collaborative research center to be operated by ECBC, but designed for collaborators to work shoulder to shoulder with ECBC researchers on key systems biology, genomics and proteomics questions through joint projects, including the potential to tap graduate and postdoctoral students. The objective should not be to replicate existing laboratory facilities at ECBC, such as its gene sequencing, mass spectrometry, bio-scale-up processing, but to augment- possibly with more modeling and informatics tools. This collaboration facility would be a modest-sized laboratory facility—less than 50,000 sq ft—built out to:

- Foster collaboration and collisional interaction.
- Create adaptable laboratories and workspaces.

An example for the design of the facility would be to consider basing it upon that used by the Institute for Systems Biology in Seattle, Washington.

Computational Sciences, Analysis and Modeling Leveraging APG's High Performance Computing Capacity

Aberdeen Proving Ground is home to one of the supercomputers managed by the Army Research Lab's Defense Supercomputing Resource Center. Supercomputing, or what is often referred to as "high performance computing", is becoming increasingly recognized across universities and other research organizations as the "third leg" to scientific research complementing the more traditional legs of theory and experiment. In particular, supercomputing enables the growth of computational sciences and represents an intersection of computer science, engineering, and applied math. The primary focus of this emerging field of computational sciences is the construction of computer-based models and numerical analysis techniques to simulate, evaluate, and solve problems through the integration of large amounts of data. Computational modeling is heavily applications oriented with particular emphasis on understanding and solving problems in areas of biology, medicine, economics, business, and the environment.

Traditionally the use of the supercomputer at APG has been focused on physics modeling and simulation in weapons and materials research, including for modeling armor design and performance and the fluid dynamics associated with energetics and combustion. But the discussions with senior APG staff reveal that interest goes well beyond. For example:

- In chemical biological pathogen research, the use of the supercomputer will be of interest as its genomics and proteomics focus moves more into systems biology, which depends upon the ability to manage and model very large datasets.
- In network centric warfare that involves the broad C4ISR mission found at APG, there is a need for use of high performance computing for network mapping and simulation.
- In testing and evaluation, there is a growing emphasis on modeling and simulation which needs to tap supercomputing capabilities.

Based on discussions with senior APG staff, it was learned that much of the expertise for programming related to high performance computing has come from universities. For instance, a major new grant for multi-modeling of materials in extreme environments was awarded to a multi-university consortium led by Johns Hopkins University. The Army Research Lab has a high performance computing center of excellence led by Stanford University that has been active at APG.

While basic research in supercomputing can be done from a distance, broader application of supercomputing for engineering solutions requires a more hands-on focus. For instance, the Pittsburgh Supercomputing Center (PSC), while a national resource, brings specialized assistance to universities in Pennsylvania and particularly in Pittsburgh. From July 2010 through June 2011, the PSC supported 685 individual Pennsylvania researchers and reached 586 Pennsylvania graduate and undergraduate students with workshops and presentations on high performance computing.

The local advantage to universities and industry in Pittsburgh of having this locally based resource is articulated clearly in the web pages of the PSC:

“PSC provides faculty and students in the Pittsburgh area with access to the most advanced, powerful, and robust collection of integrated advanced digital resources and services in the world. PSC’s technical staff has years of experience in applications and systems software design and implementation, quantitative analysis, advanced consulting, and delivering high-quality training. PSC’s staff is available to discuss faculty members’ needs and to guide them to the best solution, drawing upon the resources of PSC and of the Extreme Science and Engineering Discovery Environment (www.xsede.org) of which PSC is a leading partner.

The PSC Corporate Affiliates Program provides its industrial partners the expertise and resources to enhance and support their corporate technical computing capabilities and to exploit high performance computing technologies. With over twenty years experience in both operating an integrated high performance computing facility and in developing applications of this technology to solve critical research, engineering, and business problems, PSC can put this expertise as well as the high performance computing and communications facilities themselves to work for you. With the wide array of products and services offered, our programs are customized to meet the particular needs of our partners.”

Despite the growing demands for applications of computational sciences enabled by supercomputing at APG, there is not the broad capacity of PSC found at APG able to work across the many potential users found across the organizations of APG.

Existing university collaborations have paid dividends in new technologies developed and talent generation, but have not blossomed into broad collaborations with researchers in specific program areas at APG. Too much of the focus has been on top down collaboration and improved processes for project approvals with specific program needs are imperative. Having an intermediary specialized high performance computing technical assistance unit at APG similar to the Pittsburgh Computing Center would help in facilitating these relationships while enabling university collaborators to focus on

advancing the fundamental work on algorithms and middleware needed to address use of high performance computing for broader applications.

There are signs towards creating more capacity at APG for computational sciences. The Weapons and Materials Research Directorate (WMRD) is discussing having a node at APG to access the capabilities of a major new grant led by Johns Hopkins University that will be advancing modeling for materials in extreme environments.

Still, a more proactive approach at APG to tap the broad expertise found in computational sciences across U.S. universities would enable the organizations at APG to move strongly into realizing the applications of supercomputing-enabled computational sciences to meet their needs. This might entail establishing an APG-based University Consortium Center for Computational Sciences Analysis, Visualization and Modeling to facilitate partnerships across university computational sciences experts and APG organizations and lead to specific project-based activities. This facilitation would involve having a built out lab for visualization, data analysis and modeling that could host visiting faculty, graduate and post-doctoral students in computational sciences and allow for hands-on assistance to APG organizations.

Incubating Material Sciences Solutions

Increasingly the engineering of materials is becoming a more complex effort with the rise of multi-functional and advanced composite materials involving a convergence of technologies and more sophisticated trade-offs across key requirements. While computational sciences holds considerable potential in helping to consider this more complex world of materials solutions, there is also a growing need for more incubation type facilities to consider the trade-offs and to demonstrate different material engineering solutions.

These advanced solutions in the engineering of materials draws upon the expertise found across many actors from academic researchers to national laboratories to emerging technology companies to more established companies. Bringing this diverse community together is important as APG considers advances in materials solutions.

In universities across the nation, there is a growing focus on advancing applications centers to enhance the “lab to solution cycle” which incubate the development of new materials solutions from proof of principle to commercializable product. Application centers provide access to facilities, equipment and experts to enable industry, working in partnership with academic researchers, to adapt, develop, and utilize discoveries from the research institution. Examples of such applications centers include:

- **Oregon Nanoscience and Microtechnologies Institute (ONAMI)** takes a consortium approach across universities in Oregon and involves industry in a substantive way, and emphasizes actual development of saleable macro-scale products incorporating nano and micro-scale features. ONAMI has an active gap fund to commercialize technology and a pilot scale facility for early product definition.
- **University of Massachusetts at Amherst's Polymer research complex**, an interdisciplinary materials program which has a strong heritage in basic discovery and is well established as one of the leading polymer science programs in the world, but is also well supported by a range of large and small companies with short-term horizons oriented at actual products. Makes use of market assessment funding from a statewide Technology Transfer Center. It has developed mini-consortia around common interests, involving major materials suppliers and end-market suppliers and is beginning to see "vertical integration" between basic nanoscience and macro-scale manufacturing. Can apply to state-funded Tech Transfer Center for market assessment awards
- **Washington Technology Center's Micro/Nanofabrication Laboratory**, somewhat narrower in scope because it represents mainly a user facility rather than a research program. Nonetheless, the laboratory is concerned with creating an environment tied to the university and where companies can receive industrial-grade support for prototype manufacture. Organized as an independent non-profit corporation, WTC has its own built-in funding for commercialization research, and access to pre-seed fund at Washington Research Foundation.

From discussions with senior APG staff, there would be a substantial benefit to having a range of collaborators be able to advance their materials solutions as well as validate its applicability for military needs by having such a Materials Applications Center, which can offer flexible lab space and access to APG advanced materials labs (facilitated through collaborations with APG). This would certainly be a benefit for APG to work with companies and universities awarded SBIR and CRADAs to more actively incubate the advanced materials solutions in collaboration with APG. This Applications Center could be strategically focused on specific materials problems or needs of APG organizations, with academic or industry collaborators invited through an open solicitation process of best ideas which are then advanced at the Applications Center.

Broader Aberdeen Region Offers a Resource Rich Environment for Both University Talent and Research Activities

While there is an absence in Aberdeen, Maryland, and even across Harford and Cecil Counties, of a locally based research university, within close proximity is an extensive complex of universities. Within a 90 minute drive of Aberdeen Proving Ground are 42 universities in Maryland, Delaware, Pennsylvania and New Jersey conducting research activities and offering bachelor and graduate level degrees in computer sciences, engineering, material sciences and life sciences. According to the National Science Foundation's University Research & Expenditures Survey, these 42 institutions conducted over \$4.8 billion in total research and development, or 8.2 percent of the total U.S. university research expenditures. In just Maryland, there are 12 universities conducting research within 90 minutes of APG, with a combined total research and development spending of \$3 billion in 2010.

The proximity of this rich complex of universities to Aberdeen Proving Ground in concept can have a tangible value for advancing collaborations. By being close to Aberdeen Proving Ground, faculty and their students can more easily engage in on-site activities at APG, including conducting joint research projects and accessing key laboratory facilities. Proximity also enables offering more intensive in-person education and training courses with existing faculty on site at APG. Faculty working in close collaboration with APG organizations can build into their schedules designated days in which they are on site at APG without diminishing their responsibilities at their university campuses. Similarly, students can take on internships and joint research projects without having to necessarily relocate for periods of time.

The question is how well does this rich complex of research universities within 90 minutes of Aberdeen Proving Ground align with the technology focus and emerging opportunities for university collaborations that have been identified.

Below is a closer look at how this extensive research university complex within 90 minutes of Aberdeen Proving Ground aligns with the specific technology focus areas found at Aberdeen Proving Ground considering:

- The extent and trends in talent generation
- The level and excellence found in scholarly activity

The analysis also examines major research centers found across this research university complex found within 90 minutes

Talent and Scholarly Activity of Broader Region Across Technology Focus Areas Found at Aberdeen Proving Ground

Based on the profiles set out for each of the five specific technology focus areas involving likely talent degree requirements and research and development activities, a mapping was developed to assess the extent of both talent and scholarly activities found across the complex of universities within a 90 minute drive of APG.

For talent, specific degrees as defined by the Federal Classification of Instructional Programs (CIP) at the bachelor and graduate level were mapped to each of the six technology focus areas found at APG. The data on number and trends in the degrees awarded as mapped to each of the six technology focus areas 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 U.S.

For scholarly activity, two sources of information were analyzed. The first is research and development expenditures by field for all universities conducting research in the U.S. (nearly 800 in all) maintained by the National Science Foundation. This university research and expenditures database offers measures on level and trends in broad areas of research activity found at universities corresponding to departmental levels of activity at a university rather than detailed research study area. To probe more closely at research study areas, data on the level and research impact of peer-reviewed publications were tapped from Thomson-Reuter's University Scientific Indicators database,, which tracks major university publications activity across well over 200 discrete research study areas associated with specific peer-reviewed journals. In particular, two measures of publications activity capture how specific fields of research stand out within specific universities and groupings of universities—one is the share of U.S. publications, which measures level of activity, and the other is the level of citations per publication compared to the U.S. average for that field, which offers a perspective on the quality of publications generated.

Appendix B presents the crosswalk of degrees awarded, fields of research and development expenditures and publications areas associated with each of the five specific technology focus areas identified at APG and measured for the 95 universities within 90 minutes of APG. At the level of specific degrees and publication study areas there are some overlaps across the five specific technology fields, which suggests the multi-disciplinary nature of activities found at APG.

The results are compiled in Tables 1–3 and suggest the following:

- **The level of talent generated each year by universities within 90 minutes of APG is significant**, representing more than 4 percent of all graduates with a bachelor’s degree and higher across all the technology focus areas identified at APG and typically above 1,000 graduates annually for each the technology focus areas.
- **The one area of concern is the mixed record in growth of degrees awarded at the bachelor’s and graduate levels across the region.** The national declines in graduates in sensors, electronics and communications and information technology/software development are even deeper among universities in the broad Aberdeen region and Maryland. Yet, there are also bright spots with considerable gains in degrees related to pathogen detection & countermeasure as well as materials research.
- **The level of research and development spending in broad fields associated with the technology focus areas found at APG is quite substantial in many of the technology fields**, standing at 10 percent or higher of the U.S. total for all universities in sensors, electronics and communications, testing & evaluation and information technology and software development. Medical research is also notable, standing at 8.6 percent of the U.S., represents more than \$900 million in funded research. This broad R&D strength points to the number of top tier research universities within 90 minutes of APG.
- **In the level of publications activity, the regional universities within 90 minutes of APG are at approximately 5 percent or higher of U.S. publications for all of the technology focus areas found at APG, and also have level of quality as measured by citations per publication**, particularly for materials research, pathogen detection and countermeasures and information technology and software development.
- **Generally Maryland’s universities within 90 minutes contribute at 40 percent to 60 percent of the research and talent activity level of all the universities in the broad region within 90 minutes of APG—suggesting the sizable, but not dominant level of activities.** Other universities just outside of Maryland are also an important resource for talent and research collaborations in the technology focus areas found at APG.

The one area where Maryland’s universities within 90 minutes stands out is in the broad fields of university research and development spending associated

with the technology focus areas at APG pointing to their broad standing as research universities. When a more focused analysis of detailed publication fields are considered, the dominance of Maryland’s universities is less apparent and the broader strengths of the region relative to Maryland are revealed.

Overall, a key takeaway is that the diversity of technology focus areas at Aberdeen Proving Ground are generally well served by the universities in the broad Aberdeen region in terms of talent and scholarly activity. This suggests that the potential to grow collaborations are in place.

Table 1: Results in University Talent Generation Aligned with Five Technology Focus Areas Found at APG (All Universities in Broad Region and Only Maryland Universities within 90 Minutes of APG)

		Sensors, Electronics and Communications	Information Technology and Software Development	Materials Research	Pathogen Detection and Countermeasures	Testing & Evaluation
Number of Degrees, 2010	Universities in Broad Aberdeen Region	1434	2569	790	1387	3284
	Maryland Universities in Broad Aberdeen Region	783	1523	297	662	1603
Share of U.S. Degrees, 2010	Universities in Broad Aberdeen Region	4.2%	4.3%	13.7%	6.2%	3.8%
	Maryland Universities in Broad Aberdeen Region	2.3%	2.6%	5.2%	3.0%	1.9%
Percentage Change, 2003–2010	Universities in Broad Aberdeen Region	-7.4%	-17.4%	110.7%	110.8%	20.3%
	Maryland Universities in Broad Aberdeen Region	-11.4%	-17.4%	6.8%	66.3%	14.0%
	U.S.	-1.6%	-16.2%	58.1%	72.2%	20.8%

Source: National Center for Educational Statistics; Crosswalk and Calculations by Battelle

Table 2: Results in University R&D Expenditures Aligned with Five Technology Focus Areas Found at APG (All Universities in Broad Region and Only Maryland Universities within 90 Minutes of APG)

Technology Focus Areas Identified at APG		Sensors, Electronics and Communications	Information Technology and Software Development	Materials Research	Pathogen Detection and Countermeasures	Testing & Evaluation
		Electrical Engineering	Computer Sciences	Metallurgical and Materials Sciences	Medical Sciences	Total Engineering
Level of R&D Spending, 2010	Universities in Broad Aberdeen Region	\$279.2 m	\$161.5 m	\$33.0 m	\$1.6 b	\$1.1 b
	Maryland Universities in Broad Aberdeen Region	\$245.8 m	\$130.7 m	\$10.1 m	\$908 m	\$920.1 m
Share of US R&D Spending, 2010	Universities in Broad Aberdeen Region	13.9%	9.7%	3.6%	8.6%	11.7%
	Maryland Universities in Broad Aberdeen Region	12.2%	7.9%	1.1%	4.7%	9.8%
Percentage Change, 2003–2010	Universities in Broad Aberdeen Region	61.6%	30.7%	103.4%	47.0%	79.3%
	Maryland Universities in Broad Aberdeen Region	83.2%	29.0%	29.2%	41.4%	90.2%
	U.S.	43.5%	27.1%	69.9%	49.9%	55.8%

Source: National Science Foundation; Calculations by Battelle

Table 3: Results in Publications Activity Aligned with Five Technology Focus Areas Found at APG (All Universities in Broad Region and Only Maryland Universities within 90 Minutes of APG)

Technology Focus Areas Identified at APG		Sensors, Electronics and Communications	Information Technology and Software Development	Materials Research	Pathogen Detection and Countermeasures	Testing & Evaluation
Number of Publications, 2007–2011	Universities in Broad Aberdeen Region	5691	4804	5665	24,213	2715
	Maryland Universities in Broad Aberdeen Region	3175	2605	2351	11,833	1352
Share of U.S. Publications, 2007–2011	Universities in Broad Aberdeen Region	5.0%	5.8%	4.5%	6.9%	4.8%
	Maryland Universities in Broad Aberdeen Region	2.8%	3.2%	1.9%	3.4%	2.4%
Level of Citation per Publication Compared to U.S. Average, 2007–2011	Universities in Broad Aberdeen Region	2% higher	9% higher	16% higher	16% higher	2% higher
	Maryland Universities in Broad Aberdeen Region	1% higher	11% higher	11% higher	15% higher	3% lower

Source: Thomson Reuters, University Science Indicators; Crosswalk and Calculations by Battelle

Presence of Major Research Centers in Emerging Opportunity Areas

Beyond the alignment of regional university talent and scholarly activities in the technology focus areas found at APG, it is also important that these regional universities have leading centers of research in the critical areas of emerging technology development found across the organizations at Aberdeen Proving Ground that call for university-related talent and research collaborations that would benefit from proximity to APG.

University research centers offer a means to effectively advance specialized and tailored educational and training programs, while at the same time bringing together faculty from a range of disciplines to conduct focused research and to advance shared use laboratories and equipment. Many university research centers employ research scientists who do not have teaching responsibilities and so can be more flexible in where they are located. In addition, it is common for university research centers to organize industry consortiums interested in both pre-competitive research as well as specialized contract services, and increasingly university research centers are a focal point for more intensive commercialization services to advance new discoveries into usable products and services.

To learn about the potential for access to major research centers, Battelle examined available federal agency web sites to identify the presence of major federally funded research centers for those universities within the broad Aberdeen region across the opportunity areas of emerging development at APG that call for university-related talent and research collaborations that would benefit from proximity to APG, including:

- System of systems network development that goes to the promise of C4ISR full life cycle development
- Cybersecurity talent connections and applied research collaborations
- Systems biology tying together ongoing efforts in genomics and proteomics
- High performance computing for modeling
- Incubating material sciences solutions

While the listing is more illustrative than exhaustive, it does suggest that the universities within the broad Aberdeen region do have leading centers of research in the critical areas of emerging technology development found across the organizations at Aberdeen Proving Ground.

System of systems network development that goes to the promise of C4ISR full life cycle development

At universities in the broad Aberdeen region, there are several DoD Multidisciplinary University Research Initiative grants that support research centers involving multidisciplinary team efforts to address difficult research questions and focus on the translation of basic research findings into practical applications in the area of network sciences, including:

- A Center for Designing Reliable and Secure Mobile Ad Hoc Networks (MANETS) at the University of Maryland - College Park
- A Center for Situation Understanding Both through Language and Environment at the University of Pennsylvania, focused on generating control programs for a robot platform
- A Center for Control Science for Next Generation Sensing at the University of Pennsylvania.

There are also several industry/university cooperative research centers in network sciences supported by the National Science Foundation among universities in the broad Aberdeen region, including:

- The Center for the Visual and Decision Informatics at Drexel University
- The Center for Safety, Security, Rescue and First Response at the University of Pennsylvania
- The Rapid Response to Natural Disasters using a situational aware virtual information observatory at the University of Maryland, Baltimore County.

The focus on systems research is becoming a major emphasis for universities in the broad Aberdeen research. For instance, the University of Maryland Institute for Systems Research is an interdisciplinary research unit within the Clark School of Engineering, which was formally established in 1992 growing out of an NSF funded Engineering Research Center, and is focused on new algorithms and modeling for decision making and control, communications and computing needed to model and design large scale systems. Similarly, in 2011 Johns Hopkins University launched a Systems Institute to take a multidisciplinary approach to re-engineering entire systems of national importance, including medicine, health care delivery, network-enabled systems, information security, national infrastructure, and education.

Cybersecurity Applied R&D and Talent Development

The hallmark of excellence for universities in cybersecurity education and research is the designation by the National Security Agency and the Department of Homeland Security as either:

- A National Center of Academic Excellence in Information Assurance Education; and/or
- A National Center of Academic Excellence in Information Assurance/Cybersecurity that can support advanced academic research and development capabilities.

To qualify for either designation requires universities to pass a rigorous review based on specific and detailed criteria.

Three of the universities in the broad Aberdeen region—George Washington University, Johns Hopkins University and University of Maryland, Baltimore County -- are designated for their education and research excellence in information assurance.

Another eight universities in the broad Aberdeen region are designated as National Centers of Academic Excellence in Information Assurance Education, including: Capitol College, Drexel University, Georgetown University, Howard University , Towson University, US Naval Academy, University of Maryland University College and Wilmington University.

Plus, the University of Maryland, College Park is designated for its excellence in information assurance/cybersecurity research.

Systems biology tying together ongoing efforts in genomics and proteomics

The strength of the broad Aberdeen region in biomedical research stands out with major academic medical centers found in Baltimore, Philadelphia and Washington, D.C. Many of the funded research centers across these academic medical centers have specialized cores in genomics, proteomics and systems biology. For instance, the University of Pennsylvania has a Program in Systems Biology as a component of its NIH funded Institute for Translational Medicine and Therapeutics (ITMAT).

Still two funded NIH research centers in the broader Aberdeen region should be highlighted:

- One is the Mid-Atlantic Regional Center of Excellence for Biodefense and Emerging Infectious Diseases led by the University of Maryland, Baltimore, which is a major National Institute for Allergy and Infectious Disease center, with research programs addressing key systems biology issues such as analysis of virus/ toxin-host interactions, how various pathogens interact with the gastrointestinal and respiratory mucosa, ways to stimulate different arms of the mucosal and systemic immune system and a focused research program on discovery and development of diagnostics.
- Johns Hopkins University Center for Epigenetics of Common Human Disease is one of eleven Centers of Excellence in Genomic Science in the nation.

High performance computing for modeling

Several of the universities in the broad Aberdeen region have received federal funding for supporting high performance supercomputing facilities, including George Washington University, Johns Hopkins University, University of Maryland, Baltimore County, University of Maryland, College Park and University of Pennsylvania.

Along with the high performance computing facilities, there are three industry/university cooperative research centers funded by the National Science Foundation in the broad Aberdeen region, including:

- The High Performance Reconfigurable Computing Center at George Washington University

- The Hybrid Multicore Productivity Research Center, focusing on parallel processing algorithms and technology research questions, at the University of Maryland, Baltimore County.

Incubating material sciences solutions

The universities in the broad Aberdeen region are a power house in advanced materials development with many federally funded research centers from across civilian and DoD agencies.

Three universities in the region out of five nationwide have been designated by the U.S. Army as Materials Centers of Excellence, including:

- Drexel University
- Johns Hopkins University
- University of Delaware.

There are three NSF funded Materials Research Science and Engineering Centers in the region. As NSF explains: “MRSECs are supported by NSF to undertake materials research of a scope and complexity that would not be feasible under traditional funding of individual research projects MRSECs require outstanding research quality, intellectual breadth, interdisciplinary, flexibility in responding to new research opportunities, support for research infrastructure, and they foster the integration of research.”¹⁰

Within the Aberdeen region, there are two large MRSECs, which undertake a broader program of research and education involving several interdisciplinary research groups, at:

- University of Maryland, College Park with interdisciplinary research groups in the areas of: nanostructures/nanoparticles, polymers, semiconductor/photronics/organic electronics, multiferroics/magnetic/spintronics, condensed matter phenomena, biomolecular/biomimetic materials, and soft materials/colloids.
- University of Pennsylvania with interdisciplinary research groups in the areas of: mechanics of materials, nanostructures/nanoparticles, semiconductors/photronics/organic electronics, soft materials, condensed matter phenomena and biomolecular/biomimetic materials.

There is also a smaller MRSEC at Johns Hopkins University focused on the science and engineering of magnetoelectronics.

¹⁰ See <http://www.mrsec.org/mrsec-program-overview>

In addition, Johns Hopkins University is the lead on a recently announced U.S. Army Collaborative Research Alliance with the University of Delaware, Cal Tech, and Rutgers. This alliance has created the Hopkins Extreme Materials Institute (HEMI) to study materials in extreme dynamic environments focused on multi-scale modeling of materials in ultra-high loading rate environments. This five- year initial award with a renewal option for up to an additional five years, has an award potential of \$92 million.

Universities in the broad Aberdeen region also actively work with industry to advance new materials solutions as indicated by the large number of Grant Opportunity for Academic Liaison with Industry (GOALI) grants, including with Drexel University, Towson University, UMBC, Johns Hopkins University, University of Maryland College Park, US Naval Academy and the University of Pennsylvania.

Best Practice Lessons on Advancing University-Related Talent and Research Collaborations: Insights from Benchmark Universities and Communities

The rich resource base of universities within the broader Aberdeen region aligned with the technology focus areas and emerging opportunities found at Aberdeen Proving Ground points to the potential for advancing significant talent and research collaborations. This section examines what it will take to realize those potential collaborations not only with regionally based universities, but other leading universities found across the nation.

From discussions with key stakeholders across APG senior leadership, Harford County technology business community and universities engaged with organizations at Aberdeen Proving Ground, it became clear that there are two levels of engagement in advancing university talent and research collaborations with APG organizations:

- The first level of engagement involves what will drive specific university engagements—that is, what is the value proposition to a university in pursuing closer collaborations with a federally driven research hub such as that found at Aberdeen Proving Ground.
- The second level of engagement involves what will add value and advance a community-wide effort to involve universities in collaborating with a federally driven research hub. This second level recognizes that the community plays a key role in advancing university relationships and that the mechanisms needed are beyond the reach of just an individual university and the federally driven research hub.

Value Proposition and Issues for Advancing Specific University Engagements

To learn more about the value proposition and issues confronting specific universities in advancing talent and research collaborations with APG, Battelle identified several universities with ongoing relationships with APG and held discussions with leadership officials at these universities including:

- **University of Delaware (UD)**, which is one of the physically closer research universities to Aberdeen Proving Ground and one of the more active

collaborators with organizations at APG. UD has a long history of collaboration with DoD through its Center for Composite Materials, which is an Army Research Laboratory Materials Centers of Excellence. UD has actively partnered with organizations at APG in research through a Cooperative Research and Development Agreement (CRADA) it has in place with the U.S. Army Research, Development and Engineering Command (RDECOM), including work on antenna technology, composite materials and other technology areas. UD also has established a wide range of on-post, live lecture courses conducted primarily by university faculty, which in 2012 included the following courses:

- Advanced Engineering Electromagnetics, a graduate level course to develop a mathematical understanding of electromagnetic waves and their interactions with materials and structures.
 - High Performance Computing with Commodity Hardware, a graduate level course introducing the concepts of high performance computing and its architecture and optimization.
 - Microwave Circuit Design, a graduate level course dealing with the analysis and design of passive and active radio frequency front-end microwave circuits.
 - Magnetism and Magnetic Materials, a graduate level introductory course on basic concepts and applications involving magnetism and magnetic materials.
 - Wireless Communications, a graduate level introductory course on the fundamentals of wireless system design and basic concepts of wireless communications.
 - Digital Image Processing, a graduate level course on how sensor devices process images.
 - Digital Communications Theory, a graduate level course introducing the tool and approaches for analyzing and designing digital communications systems.
- **Georgia Tech Research Institute** has a field office located close to Aberdeen Proving Ground that offers access to training and office and lab space for researchers. GTRI is active in research collaborations involving radar, antenna and sensors with APG, particularly through its designation as a University Affiliated Research Center. GTRI has an active research relationship with

CECOM Software Engineering Center maintaining a laboratory facility at its Atlanta campus known as the Army Reprogramming Analysis Team—Support Cell Atlanta, which serves as the primary distribution point for threat updates to Army aviation, ground systems and platforms and develops software and other technologies for communications electronics used in the field. In recent years, GTRI has been active in advancing professional education courses at APG that offer highly specialized short courses on key topics of interest to APG personnel.

- **Stanford University** leads the Army's High Performance Computing Research Center that uses high performance computing to address difficult scientific and engineering challenges facing the U.S. Army. Over its initial five years of collaboration with the Army Research Laboratory, the Center has made significant contributions to advancing lightweight combat systems survivability, computational battlefield network and information sciences, computational nanotechnologies and biosciences and algorithmic development for enabling high performance computing. The Center has had extensive interactions at APG to identify and develop projects as well as to have graduate student interns at APG in the summer.
- **University of Maryland College Park**, which has significant activities with Department of Defense research including through several multidisciplinary university research initiative awards and cooperative research grants from the Department of Defense, including for mobile ad-hoc networks and multi-scale networks, cybersecurity and electronics reliability. Currently UM College Park has limited interactions with Aberdeen Proving Ground, though is actively involved with the Army Research Labs and its facilities at Adelphi, Maryland near the University of Maryland College Park campus.
- **Columbia University Center for Infection and Immunity**, which was identified by senior leadership at the Edgewood Chemical Biological Center (ECBC) in its efforts to advance genomics and proteomics. The Center is a worldwide leader in the use of molecular methods for pathogen discovery, led by Professor W. Ian Lipkin with a team of over 65 investigators, post-doctoral fellows and research and support staff. It is housed in Columbia's Mailman School of Public Health.

From these discussions a number of key value propositions and issues were identified to advance talent and research collaborations:

- **Having predictable funding mechanisms for advancing research is critical to engaging universities.** There was strong interest in advancing research collaborations on-site at Aberdeen by all of those interviewed, but the mechanisms to contract and fund such activities needs to be enhanced at APG organizations. CRADAs by themselves do not bring funding and large scale grant awards are hard to secure and often are not well focused on particular DoD locations. So, there is a need for other funding mechanisms to advance university research collaborations in a predictable manner. Another key issue expressed by one of the universities interviewed was the need to ensure the ability to publish, particularly if graduate students and post-doctoral fellows are to be heavily engaged.
- **Top down research relationships alone are not sufficient to drive university collaborations, there needs to be active engagement of APG researchers on the ground.** Even for those with major research centers awarded through DoD funding mechanisms, the critical driver of research projects is through active partnerships and engagement by APG researchers. This requires coordination and protocols for how projects are advanced within larger grant awards. In the past, there have been considerable delays for some in how project approvals are handled.
- **There is a strong value proposition between educational courses and research collaborations, but over time educational courses need to be sustainable to advance university engagement.** Those universities who are actively engaged in educational courses view them as a significant way to building relationships that can lead to broader research collaborations. At the same time, having research collaborations can benefit educational course development by enabling universities to connect courses with real world needs and challenges facing APG organizations. Still, educational courses are not sustainable as an ongoing investment by universities, and need to be self-sustaining. This requires ensuring having better mechanisms to ensure that courses being offered really are in demand and will be used by APG staff.
- **A key challenge in educational programming is going beyond individual courses and advancing degree and certificate programs.** Even for those universities actively engaged in educational courses, it has been difficult to provide a fuller educational and training service to APG staff in offering degree

or certificate programs. The strong focus on graduate education for APG staff does not translate into degree or certificate programs, which limits the educational value of university collaborations.

- **Interest is strong by students to participate in internships, summer research projects and other experiential learning interactions.** From across the universities interviewed, APG organizations are attractive to students, particularly graduate students. Increased student internship and research projects can be a key means for recruiting talent in hard to find fields and when demand for new workforce arises may be critical to ensure the level of skilled workforce needed by APG.

Community-Wide Approaches to Support University-Related Collaborations

There is a growing recognition that addressing the advancement of university collaborations with Aberdeen Proving Ground has a community dimension to it that goes beyond simply the relationship of an individual university with the military base and its organizations.

Already, Harford County has advanced a number of entities to further broader community engagement including the HEAT Center for educational activities and the newly organized University Research Partnership for broader university and industry collaborations with Aberdeen Proving Ground.

The question is what we can learn from other communities in how they have acted to advance university collaborations and furthering the development of its location as a technology hub.

Two communities were identified to benchmark on how to successfully advance more community wide activities:

- Huntsville, Alabama, home to the Redstone Arsenal, is a vast federal facility that houses the Army Missile Command, the Army Space and Strategic Defense Command, and the NASA Marshall Space Flight Center. All three entities are large performers of R&D and significant sources of federal contracts.
- Dayton, Ohio, home to the Wright Patterson Air Force Base, is today the headquarters for the Air Force Research Laboratory and home for a number of research directorates including materials and manufacturing, power and propulsion, sensors, human performance and air vehicles.

Huntsville, Alabama

Huntsville, Alabama can trace its history from a rural cotton market town and low tech textile industry center into a major technology hub¹¹ with the transformation in 1948 of Redstone Arsenal—formed at the height of WWII as a chemical weapons and ordinance facility—into a center for rocket research and development. Then, in 1950, Redstone Arsenal new research and development mission got a significant boost with the relocation by the U.S. Army of Dr. Wernher von Braun, one of the world’s renowned leaders in astronautics, rocketry and space exploration, and his team of German scientists and engineers to Redstone Arsenal. This effort was led by U.S. Sen. John Sparkman, who lived in Huntsville’s historic Twickenham neighborhood.

In 1960, NASA located its center for rocket development, Marshall Space Flight Center, as well in Huntsville. This NASA facility played a key role in creating the rockets that powered space travel to the moon, developing the space shuttle propulsion system and managing the development of the space systems needed for the space station and many scientific instruments.

Together, these two federal installations have been the drivers of Huntsville’s emergence as a major technology hub. But the community of Huntsville has played a significant role in ensuring the full potential of its technology-driven growth is maximized by advancing several key initiatives including:

- Cummings Research Park
- University of Alabama at Huntsville
- Technology Intermediary Organizations to support industry growth.

Advancement of the Cummings Research Park

The concept of a research park emerged from the needs of space and defense contractors for modern facilities in which to conduct their work. The action that jumpstarted the research park occurred in 1962 when a visionary industry leader, Milton K. Cummings, then president of the space and defense contractor Brown Engineering Company (now known as Teledyne Brown Engineering) purchased 150 acres for the development of a industry research and development facilities and pushed for the City of Huntsville create a new zoning district that formally launched the research park.

¹¹ Huntsville metro area now has 12.6 percent of its workforce in high-tech, ranking 6th in nation, right behind the Boston metro, making it a high-tech “sleeper”.

As a case study on Cummings Research Park by Georgia Tech's Center for Economic Development Services explains:

"As it became evident that Cummings Research Park provided a comparative location advantage to large and small high tech enterprises alike, the City of Huntsville and the Chamber of Commerce of Huntsville/Madison County realized the greater economic development benefits the park could provide for the Huntsville area. They formed a partnership to develop, manage, and market the park."¹²

A non-profit educational entity, the University of Alabama in Huntsville Foundation, and private partners continued to expand the park's boundaries through the 1970's to over 1,000 acres under management of the research park. Then in 1982, the City of Huntsville purchased 818 acres to add to the park and became more active in its development (in 1996 the City purchased an additional 447 acres).

In 1983, a more formal public-private partnership model emerged. By contract with the City, the Chamber of Commerce of Huntsville/Madison County markets, develops, and promotes the Park as the City's lead economic-development agent. Park affairs are governed by a Board of Directors appointed by the City. Board members include the University President and representatives of certain large industrial tenants of the Park. There is also an Advisory Board representing all companies in the Park. Finally, there is an owner-tenant association that manages common areas of the Park. There is also associated process for development approval that is managed by the research park in concert with the City of Huntsville Planning Department review and for land purchases which must be approved by the Huntsville City Council.

What stands out about the Cummings Research Park is that it focused on the co-location of technology industry with a new higher education campus (see below). Today, it houses the University of Alabama in Huntsville, a high-tech incubator known as BizTech, and the Alabama Supercomputer Center, as well as major R&D operations for leading defense contractors such as Lockheed Martin and Boeing, to name a few. The current status of the Cummings Research Park places it just behind Research Triangle Park with 300 companies employing 25,000 workers in 175 buildings encompassing 9.5 million square feet of space in over 3,800 acres of land.

Looking to the future, a new development is being advanced given the successful build out of the Cummings Research Park. It is an Enhanced Use Lease development, known as Redstone Gateway, on 470 acres of land owned by the U.S. Government. To enable more commercial real estate development for contractors and back office base operations, a

¹² Joy Wilkins, "Case Study – Cummings Research Park: A Critical Mass of High Technology Industries," Georgia Tech Center for Economic Development Services, September 1999, pg 2.

50- year, long-term lease was completed with a private developer team for a planned 4.6 million square feet of office and retail space when complete.

Establishment of the University of Alabama in Huntsville

Despite not having a university campus in Huntsville, business leaders in Huntsville formed the University of Alabama in Huntsville Foundation with the explicit purpose of advancing a research university for the community. The Foundation initially took on a joint venture role in the 1960s and 1970s in the advancement of the research park.

With the active support of Dr. von Braun, the Foundation led an active recruitment effort for a branch of the University of Alabama to be located at the Cummings Research Park with a focus on becoming a major research asset for the community. After years of only having extension services, the University of Alabama in Huntsville campus was established at Cummings Research Park in 1969.

By 2010, the University of Alabama in Huntsville has grown into a robust research university, with \$73 million in funded research. It specializes in a number of research fields critical to space and rocket R&D, including:

- Aerospace engineering with \$17.2 million in research funding for 2010, representing 2.75 percent of all U.S. university research funding in this field.
- Computer sciences with \$17.0 million in research funding for 2010, representing 1.0 percent of all U.S. university research funding in this field.
- Atmospheric sciences with \$6.7 million in research funding for 2010, representing 1.6 percent of all U.S. university research funding in this field.
- Astronomy with \$6.0 million in research funding for 2010, representing 1.1 percent of all U.S. university research funding in this field.

The University of Alabama in Huntsville has also focused on establishing key centers of excellence. 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 focused 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. Planning is underway for this new center of excellence.

At the same time, the University of Alabama in Huntsville has become a critical education provider for top talent in Huntsville. It has a total undergraduate enrollment of 5,828 in FY 2010 of which 4,501 are full time students and 1,327 are part-time. At the graduate level, it served 1,609 students in FY 2010 with 1,135 going part-time, reflecting the important continuing education role it plays. In terms of degrees its two largest programs are in engineering and business programs, which are roughly 2/3rds undergraduate and 1/3rd graduate. It also generated 18 engineering PhDs in FY 2010.

A recent news article on a meeting of the Trustees of the University of Alabama System that focused on the importance of the University of Alabama in Huntsville to the community said it all: "UAH is the 'goo in the glue' that holds high-tech Huntsville together."

Technology Intermediaries Play Active Role in Technology Industry Development

Along with the Cummings Research Park and the University of Alabama in Huntsville, there are a number of intermediary technology development organizations that play an active role in advancing technology-based economic development for Huntsville.

One of the longer standing organizations is BizTech, a 40,000 sq ft technology incubator created in 1997, which offers both space and mentoring services. There is participation in the incubator from NASA Marshall's technology transfer office, the State, the City and the Chamber of Commerce. The Chamber of Commerce operates a "technology transfer" committee that specializes in connecting entrepreneurs with the correct resources at either the University or one of the federal laboratories.

In 2006, business leaders in Huntsville advanced the Von Braun Center for Science & Innovation to serve as a catalytic research and development organization to advance the design and development of engineering concepts and prototypes to serve key federal customers. The focus of VCSI is to be a facilitator to identify specific high impact projects and organize project teams drawn from industry member firms, UAH and other national partners to advance technologies from engineering to prototypes to deployment ready. For example, one of VCSI's recently completed projects is the Multi Function Agile Remote-Controlled Robot, or the MARCBOT, a small robotic platform aimed at inspection of suspicious objects during IED Sweeps. The VCSI team upgraded the robot, increased its range, visual acuity, enabled access to FalconView and Google, provided some autonomy, and other key attributes. Ongoing projects include the development of a Lunar Lander Robotic Test Bed (LLTB) for NASA, a microsatellite that would fly experiments for DOD and a Hurricane Imaging Radiometer instrument to assess hurricane intensity information that cannot be observed by other sensors for NOAA.

A very recent activity is funding from the Small Business Administration to support for an Advanced Defense Technology cluster initiative to provide business training and guidance for small and emerging technology businesses to gain access to defense industry activities. It represents a collaboration of VCSI, the Chamber of Commerce, UAH, BizTech and the Defense Acquisition University.

Dayton, Ohio

Dayton has had a long, proud history of innovation. At the turn of the century, it was one of the industrial leaders in the state and one of its most prosperous cities. It's known as the birthplace of the Wright Brothers, inventors of the airplane, Charles Kettering, inventor of the automobile self-starter, and John H. Patterson, founder of National Cash Register. Despite some recent setbacks—the departure of NCR, a Dayton institution since its founding in 1880, and the December 2008 closing of General Motors' Moraine plant, which employed approximately 2,500 people at the time the closing was announced—Dayton is still innovating.

Today innovation in Dayton involves collaboration between the community and public and private sectors, and revitalization of its existing assets or anchor institutions, such as universities and research facilities. As manufacturing began to trickle out, Dayton looked at its still-thriving assets, including a technology base, anchored by two prominent institutions in the city—Wright-Patterson Air Force Base and the University of Dayton. And those institutions are among the stakeholders stepping in to fill the gap and pave the way for future growth.

What is today known as Wright Patterson Air Force Base, has always played a prominent role within the Dayton community. Beginning in the 1910s, with World War I's outbreak, the United States government began investigating the use of airplanes in war. In 1913, President Woodrow Wilson created the National Advisory Committee on Aeronautics (NACA). This committee suggested establishing a center to research the use of airplanes in the military and also to seek improvements in airplane technology. Due to the presence of several automobile and aircraft plants in Ohio, the NACA established this center at McCook Field in Dayton, Ohio.

By 1924, the United States Air Corps had outgrown the facilities at McCook Field. Hoping to keep the Air Corps in Dayton, the city officials and residents donated 5,250 acres of land on the city's outskirts. The Air Corps accepted the land and built Wright Field on the site. The base was named Wright Field to honor Orville and Wilbur Wright's contributions to flight. The Wrights had tested many of their early airplanes in the vicinity of Wright Field. Wright Field formally opened in 1927.

Despite Wright Field's existence, the United States Army Air Corps entered World War II at a severe disadvantage numerically and technologically when compared to the Air Forces of other nations. To help overcome these weaknesses, the federal government, in 1940, designated 300 million dollars to improve Wright Field and to create an Air Corps with at least 5,500 planes. In 1941, only forty buildings existed at Wright Field, but by 1944, the airfield consisted of more than three hundred buildings. During World War II, research continued on airplanes, with much attention focused upon improving the horsepower of plane engines, airplanes' ranges and maneuverability, safety features for crews, and weapons.

Upon World War II's conclusion, Wright Field continued to play a major role in aircraft research and construction. In 1947, the United States government created the United States Air Force, eliminating the Army Air Forces and establishing a new branch to the United States military. That same year, the Air Force combined Wright Field with nearby Patterson Field, creating Wright-Patterson Air Force Base. Throughout the next forty years, Wright-Patterson Air Force Base would continue to grow both in its size and scope. Today, Wright-Patterson Air Force Base is one of the largest air base wings in the Air Force. It has over 27,400 employees and 68 tenant units and generated a total economic impact in the Dayton area of \$5.1 billion in 2009. In addition, Wright Patterson is the headquarters for the Air Force Research Laboratory (AFRL), which is dedicated to leading the, development, and integration of war fighting technologies. Five of its ten directorates operate from WPAFB:

- Materials and manufacturing
- Power and propulsion
- Sensors
- Human Performance
- Air Vehicles.

These directorates account for 53 percent of AFRL's total R&D budget or nearly \$2 billion in R&D funding. Under the 2005 BRAC, more than 1,000 scientists and engineering positions moved from other U.S. locations to serve at AFRL in Dayton.

Clearly, Wright Patterson has been a major driver of Dayton's re-emergence as a hub of innovation. But the key stakeholders within the Dayton region have also played a significant role in ensuring the full potential of its technology-driven growth is maximized by advancing several key initiatives including:

- Development of the University of Dayton Research Institute
- Focus on Collaborative Research Projects to Leverage Research Assets
- Technology Intermediary Organizations to support industry growth.

Development of the University of Dayton Research Institute

The University of Dayton is a private Roman Catholic university. The full-time undergraduate student enrollment is around 7,500, and total student enrollment is about 11,000. The university offers more than 70 academic programs in arts and sciences, business administration, education and allied professions, engineering and law. What makes this private college unique is the University of Dayton Research Institute (UDRI), a research division of the University that focuses on not only conducting scientific and engineering research, but commercializing its discoveries for government, industrial and nonprofit clients.

The founding of UDRI has ties to the Air Force. In 1949, a Marianist priest and a mathematics professor at the University of Dayton saw an Air Force request for research assistance as an opportunity to play a role in America's postwar reconversion economy—as well as to provide new opportunities for faculty and jobs for students paying their way through school.

Three years later, UD hired five full-time researchers to support its growing number of contracts—a bold move for a small Midwest Catholic university focused on undergraduate teaching—and in 1956, with 20 sponsored projects underway, the need for a centralized research organization became clear.

On Sept. 1, 1956, the University of Dayton Research Institute was created. Sponsored research has grown from \$1 million from those 20-plus contracts in 1956 to more than \$100 million from nearly 1,500 contracts today; cumulative research revenue topped the \$1-billion mark in 2003. This is especially significant in that UDRI, its research and its 400 engineers, scientists and support staff, are funded solely by contracts and grants from external customers.

In many ways, UDRI works as a contract R&D firm, with one of its major clients being Wright Patterson Air Force Base. It focuses on providing its customers quality research outcomes and engineering solutions to the most demanding problems, on budget and on time. Unlike many universities, UDRI distinguishes itself by offering customers quick and flexible contracting options. Depending on the scope of the project and customer requirements, UDRI can work through purchase orders, as well as through firm-fixed-

price, time-and-materials or cost-reimbursement contracts. UDRI also offers its government customers the following contract vehicles:

- A GSA Schedule that allows federal customers to efficiently contract professional engineering services
- The Design and Engineering Support Program (DESP) administered through the Sustainment Technologies Integration Office.

UDRI understands the value of proprietary information and will work under publication restrictions. UDRI has a flexible approach to intellectual property rights that is significantly less restrictive than most university-based organizations.

“Our researchers are all entrepreneurs,” said John Leland, director of the Research Institute. “Their livelihood—as well as that of the support staff and the Institute itself—depends upon their aggressively pursuing and winning contracts. That makes customer service priority one.”

The Research Institute has excelled in materials research—the National Science Foundation recently ranked UD second in the nation among colleges and universities in sponsored materials research for a third consecutive year—while also developing significant expertise and capabilities in the fields of aerospace, nanotechnology, fuels, energy, environment, aging systems, structures and impact physics.

“The work performed by our scientists and engineers has and will continue to fulfill the research and engineering needs of our nation’s government and industry,” Leland said. “In addition, our efforts to transition research from the lab to the marketplace has fostered economic development in the Dayton region and Ohio, and is playing a key role in helping position our community as a national resource for advanced commercial technologies.”

Specific areas of research focus include work to:

- Reduce dependence on foreign oil by developing alternative energy sources, including jet fuel from coal, extended-life batteries, and superior insulating materials capable of heat storage and energy conversion
- Extend the life and improve the safety of America’s aging aircraft fleet
- Develop a bio-agent detection and filtration system to safeguard the nation’s drinking water from a bio-terrorist attack
- Develop new, lighter-but-stronger armor to protect America’s troops

- Develop technologies that will facilitate high-speed access to space
- Develop web sites and tools that allow people who are blind to navigate the Internet.

UDRI has continued to experience significant growth and economic reliance within the Dayton Community. In 2009, the United States Air Force awarded a \$50 million contract to UDRI for fuel technology research for aerospace applications. In 2011, The United States Air Force awarded a \$24.5 million contract for the development and testing of polymer materials and paints. As a result of this growth, in December 2009, the University of Dayton Research Institute announced that they would be relocating to the former NCR world headquarters building, helping to ensure that an economically depressed area of Dayton would see economic revitalization. This came at the same time that the Governor named the Dayton Region the Aerospace Hub of Innovation for the State of Ohio.

Focus on Collaborative Research Projects to Leverage Research Assets

The Dayton Region, through the leadership of UDRI, has sought to leverage the research strengths of Wright Patterson by creating collaborative research consortiums and activities to promote economic development. **The Institute for the Development and Commercialization of Advanced Sensor Technology (IDCAST)** is one example. IDCAST is a world-class center of excellence in remote sensing and Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) sensing technology. Leveraging the strengths of Wright Patt, and led by UDRI in collaboration with a number of academic, government, and business organizations, IDCAST was established as a Wright Center of Innovation through a \$28 million Ohio Third Frontier award. The center aims to build on Ohio's existing Federal, academic and industrial strengths in sensor technology, resulting in more rapid commercialization of sensor technology for medical, environmental and military applications. Located in Dayton's Tech Town business park, IDCAST provides 4,600 square meters of collaborative lab space, research facilities and incubator space for startup companies, enabling access to sensor test-beds and other cutting-edge equipment including the world's most advanced infrared camera.

Created in 2007, IDCAST has already played an important catalytic role in connecting Ohio sensor technology companies with new markets and opportunities for research and commercialization collaboration. Especially important is the connection that IDCAST provides to link Ohio companies and universities to the Air Force Research Laboratory (AFRL).

Examples of successful collaborations include:

- Woolpert, a Dayton-based design, engineering, and geospatial firm, was not connected to the AFRL. Woolpert credits IDCAST with helping to make the connection and Woolpert has since won approximately \$4 million in contracts from AFRL, resulting in the creation of 45 jobs (and keeping AFRL contract dollars in the state). The work with IDCAST has also contributed to another \$4.5 million in contract work with the Army. IDCAST has also helped Woolpert to connect to university expertise, such as that at the University of Dayton Ladar and Optical Communications Institute. Woolpert has also gained access through IDCAST to high-throughput computing, enabling Woolpert to automate many photo interpretation tasks, and keeping work in Ohio that would otherwise have been outsourced to use low-cost labor overseas.
- IDCAST purchased the world's most advanced infrared camera from the Cincinnati Electronics Division of L-3 Communications. The \$4.2 million camera purchase will help keep both IDCAST and L-3 Cincinnati Electronics (CE) working at the frontiers of remote sensing and infrared technology. This, in turn, is helping position L-3 CE to win possible contracts with the Defense Advanced Research Projects Agency (DARPA) and the U.S. Naval Research Laboratory (NRL). As a result of this camera technology, along with related developments, L-3 CE has been able to create 70 jobs over the past three years.
- STAN Solutions, a Dayton-based network systems and sensor technology company, was considering relocating to California to find skilled workers. IDCAST was able to provide access and connections to the sensor technology talent pool in Dayton, enabling STAN Solutions to stay in the area and expand from 14 to 32 employees. IDCAST also helped to broaden STAN Solutions' client base, from being a subcontractor to a single military prime contractor to working with multiple clients in both military and civilian markets.
- Overall, IDCAST is working "to create new companies, grow existing companies and attract out-of state companies to Ohio, to bring sensor technology to market through an alliance of university researchers, the U.S. Air Force and industry," said Larrell Walters, IDCAST Director. "We have the strength of six universities and can help these companies gain significant and sustainable advantages. All they have to do now is take a short trip to IDCAST and leverage its equipment, expertise and test facilities."

Technology Intermediary Organizations to Support Industry Growth

The Dayton Development Coalition, a regional economic development and advocacy organization whose mission is to support job creation and prosperity for the citizens of the Dayton Region, has been credited by many with being the key authors and champions of a regional strategy that has focused on supporting the further development of Wright Patterson and commercializing its technology within the region. In their own words, the Dayton Development Coalition is “focusing on expanding the awareness of our aerospace & defense initiatives, supporting commercialization efforts in leading industries, and continuing business recruitment efforts in concert with each other.”

Specific initiatives to this end include the following:

- **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. The first collaborative research project, Sensor Aided Vigilance (SAVIG), was sponsored by AFRL and hosted at WBI. It was successful in accelerating technology innovation, transition and commercialization. In addition, the AFRL Center for Rapid Product Development began operations at Tec^Edge Works. Wright Brothers Institute was awarded the 2010 Dayton Business Journal Not-For-Profit Business of the Year for its innovative programs and invigorating multidisciplinary collaboration.
- **Tech Town:** Tech Town is Dayton’s technology-oriented commercial park located on the site of a former GM factory in Downtown Dayton. Over the last several years, the City of Dayton has leveraged resources with a variety of partners to drive this cutting-edge project. Tech Town is less than a 10 minutes drive from Wright-Patterson Air Force Base. Tech Town serves as a setting where business, academia and government work together strategically to support the region’s core competencies. A major emphasis of this collaborative spirit is technology commercialization—taking technologies developed at WPAFB and other regional R&D facilities, and applying them to commercial uses.

Currently there are 10 building sites available for sale or build-to-suit which will accommodate buildings ranging from 20,000 to 100,000 square feet. The Master Plan envisions that ultimately Tech Town will encompass approximately 400,000 square feet of office and research space and accommodate up to 2,500 new jobs.

Within Tech Town there are three technology intermediary organizations that provide services to companies. They include:

- **Dayton RFID Convergence Center**, which assists in the formation and growth of early stage RFID, sensor, and data management and mining technology businesses.
- **The Entrepreneur Center**, which provides incubation services and leased space to start-ups involved in information technology, biomedical technology, and prototype manufacturing.
- **National Composite Center**, which creates large-scale manufacturing methods, establishes industry standards, and develops and applies advanced composite technology to aerospace, defense, ground transportation, and infrastructure markets.

In addition, IDCAST (mentioned earlier) is also located within Tech Town.

Key Lessons

Both the community benchmarks of Huntsville, Alabama and Dayton, Ohio demonstrate that community-wide engagement and initiatives can matter significantly in advancing university talent and research collaborations with military research and engineering organizations.

Leadership is critical for advancing community wide efforts to advance university collaborations with military research and engineering organizations. In the case of Huntsville that leadership came from initially from two visionary leaders, Milton K. Cummings who led a major technology business, and Dr. Wernher von Braun, a leading scientist at Redstone Arsenal, and was quickly institutionalized by the Chamber of Commerce and City of Huntsville. In the case of Dayton, the community engagement has happened over decades, with the City in the 1920s embracing the opportunity to have an Air Force Base in the community by donating land, then again in the late 1940s visionary faculty at University of Dayton advanced research activities that led to the creation of the UD Research Institute and today the broad community involvement is led through the Dayton Development Coalition.

Advancing a lead local university presence is essential and can be done from scratch and in consortiums. Both Huntsville and Dayton have had to invent a local university solution to serve as the main university collaboration vehicle for their region. In the case of Huntsville, it was conceived whole cloth, while in Dayton it involved the conversion of a more liberal arts college into a research university. From recent activities at Dayton, there appear to be consortium-based mechanisms that might inform how APG collaboration with universities is best advanced. Two consortium models are in place in Dayton: 1) the Institute for the Development and Commercialization of Advanced Sensor Technology, an Ohio Third Frontier Wright Center; and 2) the Wright Brothers Institute, a university consortium intermediary that engages universities from around the region and creates innovation centers off the base to collaborate with Wright Patterson AFB organizations (using a Partnership Intermediary Agreement with Wright Patterson AFB).

Having physical, shared use facilities located in the community, including at research parks, offer real value to advancing collaborations. In Huntsville, the formation of a research park offered the momentum and location for establishing a new university research campus. In Dayton, a technology park primarily for industry has offered a location for one of the university consortiums to create a shared use facility, while free standing innovation centers affiliated with university consortiums have also been launched.

A Call to Action for Accelerating University-Related Talent and Research Collaborations with Aberdeen Proving Ground

This independent, fact-based assessment of the business case for advancing a strong university resource presence in Northeastern Maryland finds both a strong value proposition for Aberdeen Proving Ground (APG) organizations and specific opportunities for advancing university collaborations, while a rich complex of universities within 90 minutes of Aberdeen that align strongly with the technology focus areas and emerging opportunity areas found across APG organizations for which closer proximity can be advanced.

From a talent perspective, closer proximity of university collaborators can advance much needed master's level education programs that couple teaching basic methods with more hands-on learning and applications development to create more "journeyman" scientists and engineers.

At the same time, closer proximity of university collaborators would offer the opportunity to establish relationships and improve the ability to recruit doctoral students and post-graduate fellows working on APG-related research projects for basic research at APG.

In research, close proximity of university shared use facilities supported by APG organizations would enable a more interactive environment between APG researchers and university researchers to address both thorny multi-disciplinary research challenges and to speed the pace of research advances. So, while not important for improving the quality of university efforts on their own research projects, it would raise the broader level of science and creativity for APG's own research efforts.

This business case is strengthened by the rich complex of universities within 90 minutes of Aberdeen that align strongly with the technology focus areas and emerging opportunity areas found across APG organizations for which closer proximity can be advanced. By having such a rich complex of universities within 90 minutes of Aberdeen Proving Ground, faculty and their students can more easily engage in on-site activities at APG, including conducting joint research projects and accessing key laboratory facilities. Proximity also enables offering more intensive in-person education and training courses with existing faculty on site at APG. Faculty working in close collaboration with APG organizations can build into their schedules designated days in which they are on site at APG without diminishing their responsibilities at their university campuses. Similarly,

students can take on internships and joint research projects without having to necessarily relocate for periods of time.

But without focused actions to address the missing presence of university resources proximate to Aberdeen Proving Ground this business case and the potential to offer a world-class technology location in the Aberdeen region that fully maximizes the potential of Aberdeen Proving Grounds will fall short.

What stands out is that there is currently no mechanism found across the organizations at APG to advance collaborative approaches with universities on talent development and R&D to co-locate in Harford County. One suggestion was to create an intermediary entity governed by an APG Science & Technology Council led by representatives drawn from across the APG organizations. The focus of the APG Science & Technology Council would be to facilitate cross-organizational need identification for university-related talent development and research collaborations and possible business models and policies. A university advisory council could work alongside the APG Science & Technology Council and help in refining approaches and policies around identified needs to further engage university partnerships. The universities serving on the advisory council might be drawn from those universities with active CRADA relationships with APG organizations. A full time staff director position would need to be established, possibly as a loaned executive from APG. Administrative support would also be needed, and might possibly be accessed through the Chesapeake Science and Security Corridor.

Best practices also suggest that Harford and Cecil Counties need to play a key role in advancing community efforts to promote more university presence in the region. The community benchmarks of Huntsville, Alabama and Dayton, Ohio demonstrate that community-wide engagement and initiatives can matter significantly in advancing university talent and research collaborations with military research and engineering organizations. These two community benchmarks offer the following insights:

- Leadership is critical for advancing community wide efforts to advance university collaborations with military research and engineering organizations.
- Advancing a lead local university presence is essential and can be done from scratch and in consortiums.
- Having physical, shared use facilities located in the community, including at research parks, offer real value to advancing collaborations.

The opportunity and value of moving forward with accelerating university-related talent and research activities located close to APG are clear as is the potential value of working

with the rich complex of universities within the broad Aberdeen region. But a focused strategy and specific action plan is needed to address the challenges and realize the potential for creating a world class technology hub with a vibrant university presence at APG.

Appendix A: Senior Civilian Staff at Aberdeen Proving Ground Interviewed by Battelle

Name	Title	Organization
Paul DeBenedictis	Human Capital Manager	RDECOM
John Pellegrino	Director, Computational and Information Sciences Directorate	Army Research Laboratory
Ned Keeler	Director, US Army CECOM, Software Engineering Center	CECOM-Software Engineering Center
Brian Simmons	Executive Technical Director, Deputy to the Commander	US Army Test Evaluation Command (ATEC)
Joseph L. Corriveau	Director of Research and Technology	ECBC
Gary Martin	Deputy to the Commander	CECOM
Mike Lombardi	Deputy Director, Intelligence and Information Warfare	CERDEC
Paul Tannenbaum	Director, Survivability/Lethality Analysis Director	ARL
Patrick Baker	Director, Weapons and Materials Research Directorate	ARL
Douglas Bryce	Chemical and Biological Defense	Joint Program Executive Office
Christina Weber	Manager	Army Medical Research Institute of Chemical Defense

Appendix B: Crosswalk of University Talent Generation, Research & Development Expenditures and Publication Areas

Technology Focus Areas Identified at APG	Talent – Crosswalk of Specific Degrees Awarded by Universities	Scholarly Activity	
		Broad Fields of University R&D Expenditure	Publication Activity in Peer-Reviewed Journals by University
Sensors, Electronics and Communications	Systems Engineering Modeling, Virtual Environments & Simulation Computer Engineering Computer Hardware Engineering Computer Software Engineering Electrical & Communications Engineering Telecommunications Engineering Command & Control Systems	Electrical Engineering	Acoustics Automation & Control Systems Cybernetics Electrical and Electronic Engineering Nanosciences Optics Remote Sensing Robotics Telecommunications
Information Technology and Software Development	Systems Engineering Computer Engineering Computer Hardware Engineering Computer Software Computer and Information Sciences Information Technology Informatics Computer Programming Computer Science Data Modeling/Warehousing & Database Administration Computer Graphics Computer Software and Media Applications Computer Systems Networking System Administration System Networking Computer & Information Systems Security Information Technology Project Management	Computer Sciences	Artificial Intelligence Computer Hardware and Architecture Information Systems Computer Interdisciplinary Applications Software Engineering Computer Sciences Theory & Methods Information Sciences Telecommunications
Materials Research	Systems Engineering Modeling, Virtual Environments & Simulation Mathematics & Statistics Ceramic Sciences & Engineering Materials Engineering Metallurgical Engineering Polymer Engineering Polymer Chemistry Chemical Physics Material Sciences Materials Chemistry	Metallurgical and Materials Engineering Chemical Engineering	Chemical Analytical Sciences Chemical Engineering Ceramics Material Characterization and Testing Coatings and Films Composites Multidisciplinary Material Sciences Metallurgical and Metals Engineering Nanoscience Polymer Science

Continued on following page

Technology Focus Areas Identified at APG	Talent – Crosswalk of Specific Degrees Awarded by Universities	Scholarly Activity	
		Broad Fields of University R&D Expenditure	Publication Activity in Peer-Reviewed Journals by University
Pathogen Detection and Countermeasures	Analytical Chemistry Biomedical/Medical Engineering Biomedical Sciences - General Molecular Biology Molecular Biochemistry Structural Biology Cell/Cellular Biology and Histology Developmental Biology and Embryology Cell/Cellular and Molecular Biology Cell Biology and Anatomy Cell/Cellular Biology and Anatomical Sciences - Other Microbiology - General Medical Microbiology and Bacteriology Virology Parasitology Immunology Microbiology and Immunology Microbiological Sciences and Immunology - Other Genetics - General Human/Medical Genetics Genome Sciences/Genomics Genetics - Other Pharmacology Molecular Pharmacology Neuropharmacology Toxicology Molecular Toxicology Environmental Toxicology Biostatistics Bioinformatics Computational Biology Biomathematics and Bioinformatics - Other Biotechnology	Biological Sciences Medical Sciences Bioengineering/Biomedical Engineering	Biochemistry & Molecular Biology Biochemistry Research Methods Biotechnology & Applied Microbiology Chemical Analytical Sciences Medicinal Chemistry Organic Chemistry Development Biology Immunology Infectious Diseases Computational Biology Parasitology Pathology Pharmacology Tropical Medicine Virology
Testing & Evaluation	Systems Engineering Modeling, Virtual Environments & Simulation Computer Engineering Computer Hardware Engineering Computer Software Engineering Electrical & Communications Engineering Civil Engineering Engineering Mechanics Mechanical Engineering Industrial Engineering Operations Research Applied Mathematics Computational Mathematics Statistics Mathematical Statistics Mathematics & Statistics	Total Engineering Mathematical Sciences	Chemical Analytical Sciences Industrial Engineering Mechanical Engineering Microscopy Operations Research Statistics and Probability

Sources:

National Center for Educational Statistics for degrees awarded by universities
 National Science Foundation for university research and development expenditures
 Thomson Reuters University Science Indicators for publications activity

