The Southern Maryland Initiative for Energetics Capability Development

Annual Report

January 20, 2009

www.cecd.umd.edu
www.etcmd.org

Foreword

Established in 1998, the Center for Energetic Concepts Development (CECD) at the University of Maryland, College Park, celebrates its tenth year of making significant contributions to the field of Energetics. The most important of these contributions is the establishment of The Energetics Technology Center (ETC) in La Plata, Maryland. The ETC, an independent non-profit organization, applies advancements in science and technology to strengthen and expand the nation's energetics capability. The ETC is a catalyst for shaping a future science and technology workforce, accelerating regional economic development, and creating marketable technology products.

This document entitled the *Southern Maryland Initiative for Energetics Capability Development: Annual Report FY09* provides an overview of accomplishments of the CECD/ETC Enterprise after two full years of operation of the ETC in Southern Maryland. It is the fifth in a series of documents for the *Southern Maryland Initiative for Energetics Capability Development: A Response to Emerging National Needs.*

The CECD/ETC team, working together with the College of Southern Maryland (CSM), the Naval Surface Warfare Center Indian Head Division (NSWCIH), and other entities, conducts a wide range of scientific and technology activities, policy/planning studies, and workforce development programs to advance the development of energetic systems and recapitalize the nation's energetics workforce.

The development of the Indian Head Science and Technology Park in Charles County continues to progress. A notable achievement this year was bringing a world-class energetics company from the U.K., Martin Baker, to the Park. When fully occupied the Park shall be an important economic engine for Charles County and Southern Maryland. It will also be the future home of the ETC.

With continuing strong support, the CECD/ETC Enterprise is now poised to grow rapidly in establishing NSWCIH, Charles County, and the University of Maryland as important contributors and resources in the field of energetics so critical to national security.

Davinder K. Anand
Professor and Director
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Executive Summary

The CECD/ETC Enterprise activities consist of four focus areas. They are:

1. Energetic systems and processing research - conducted primarily at the University of Maryland, College Park, Maryland.
2. Applied research and technology development - performed by The Energetics Technology Center largely in Charles County Maryland facilities in partnership with selected industry/technology institutions.
3. Workforce development - recapitalizing the national energetics intellectual capability through the combined efforts of the CECD and ETC.
4. Policy and strategic analysis - formulating, in partnership with NSWCIH, a strategic business case for energetics in Southern Maryland.

These activities are a logical expansion of the highly successful science and technology conducted for the past ten years by the CECD at the University of Maryland and supported by NSWCIH.

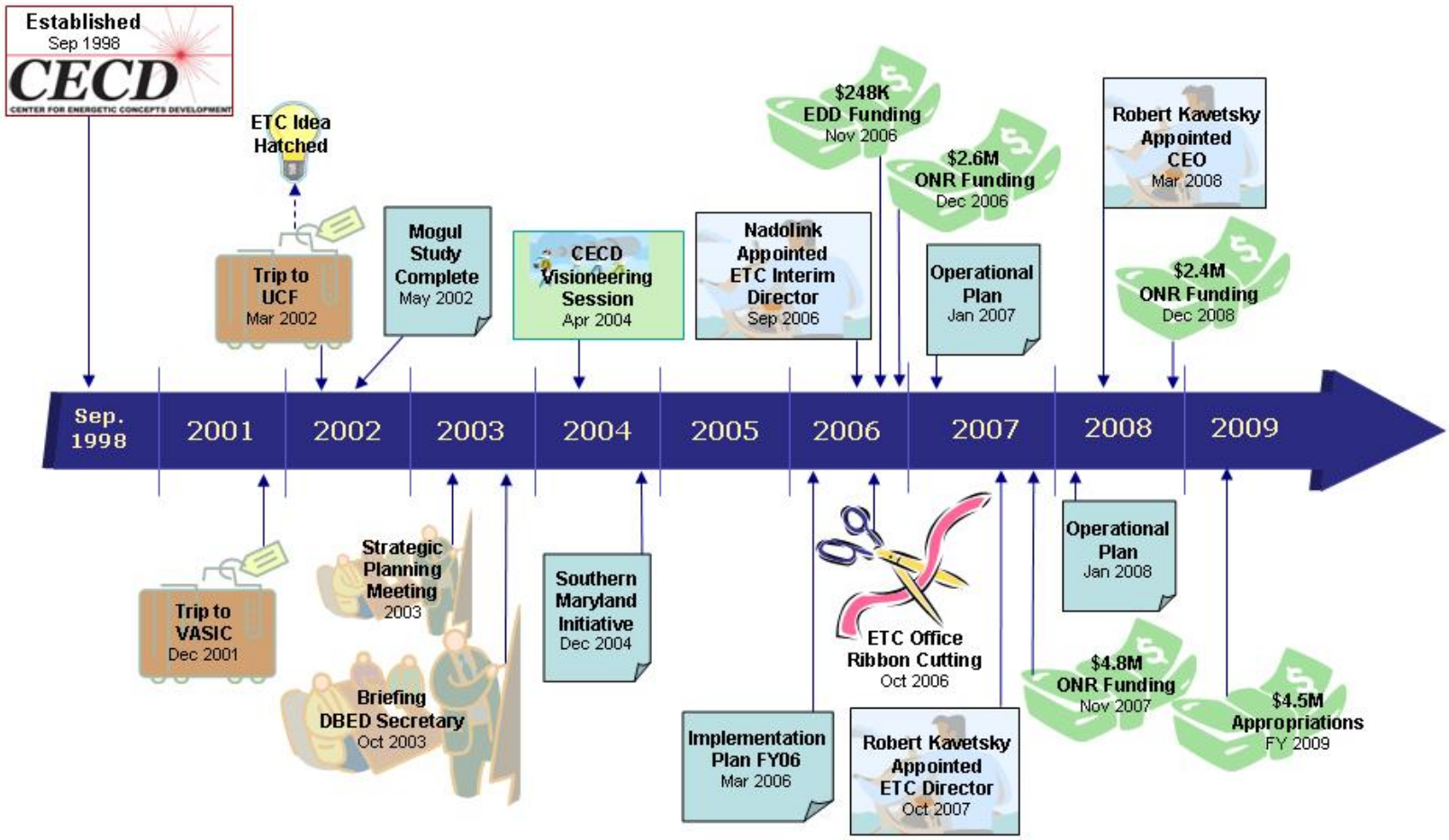
The Energetics Technology Center (ETC) was established *to be a catalyst for research, development, prototyping, education and training in Southern Maryland and to facilitate, in partnership with NSWCIH, Southern Maryland becoming a world class Center of Excellence in Energetics*. This need for energetics and energetic systems arises from two pressing issues, both critically linked to U.S. national security: the first to regenerate the energetics professional workforce and the second to develop ever more sophisticated systems in a timeframe that will ensure that the Department of Defense has the state-of-the-art capabilities.

Southern Maryland has a long history of contribution to the field of energetics development for ordnance applications. The base at NSWCIH has been a leader in Navy ordnance development and testing for over 100 years. The CECD/ETC team has met the milestones for FY08 established in the *Operational Plan* (January 15, 2008). The ETC is now a fully functional non-profit organization with 10 full-time employees and 9 part-time employees and consultants.

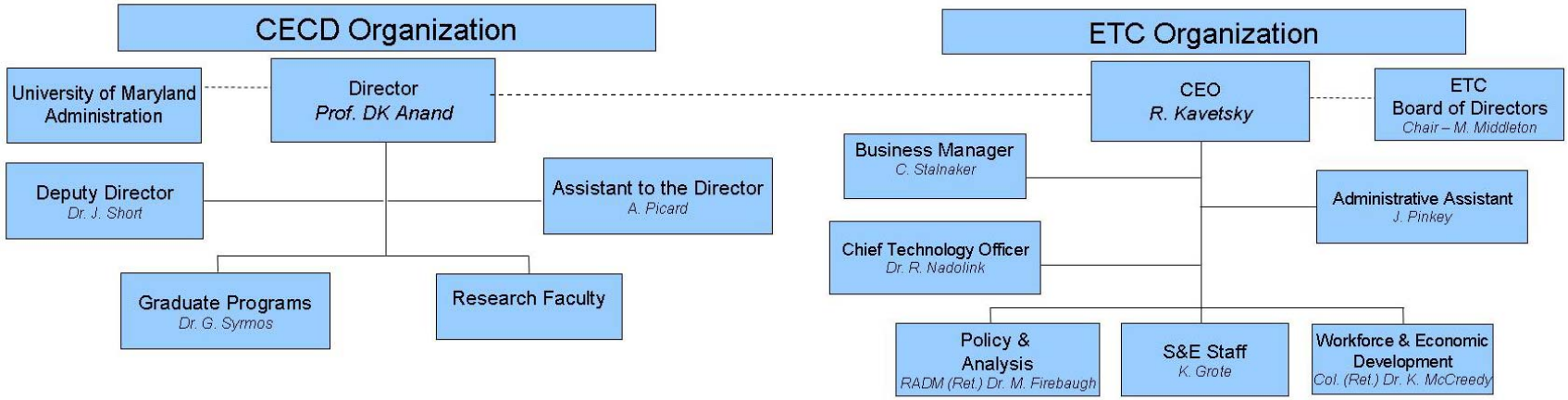
The CECD/ETC Enterprise has been involved in a number of activities supported by the Office of Naval Research (ONR) and additional contracts. Projects included Training in Virtual Environments; Health Monitoring of Energetics; a Business Case Study of NSWCIH; Shock Wave Detonics; Explosives Detection; Science, Technology, Engineering, and Mathematics Outreach; and various support activities. In addition, we have made a strong push for broadening our funding base. Marketing activities at several other agencies are being pursued. With the establishment of both near- and long-term projects that build the technical foundation for future viability and growth of the Enterprise, funding in future years is anticipated from a combination of Department of Defense organizations, other federal and state agencies, and industry. Projects such as Redesign of Helmets for Mitigating Brain Injuries, Design of an Energetic Data Warehouse, and Workforce Development Strategies are currently being marketed.

The United States Congress has provided funds for programmatic support of the ETC and enhancing the work of the CECD. These funds have been crucial to achieving our objectives in establishing Southern Maryland as an Energetics Hub. The continuation of this support is vital for establishing a strong presence in this area and in partnership with NSWCIH establishing a world class center in Energetics.

Growth of the CECD/ETC Enterprise



CECD/ETC Enterprise



Contract Performance

Ultra Sensitive Detection of Low-Vapor Pressure Compounds by Ion-Nucleation Detection (INDe)

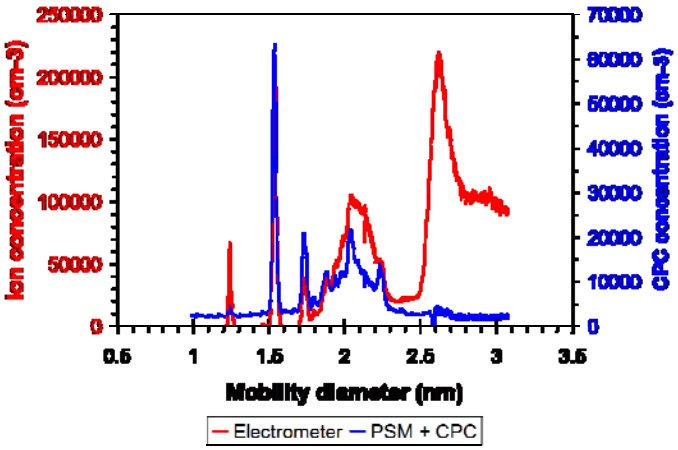
We are working to develop an ultra-sensitive method (sub-PPT) for nearly single-molecule detection of explosives and other low-vapor pressure compounds, that will improve sensitivity by several orders of magnitude over traditional ion-counting. The basic concept relies on a new approach to measure the presence of a molecule. Unlike traditional mass-spectrometry or optical methods that rely on a direct transduction of an electrical signal coming from the analyte (which greatly limits sensitivity), *our method relies on the very rapid gas-to-liquid transition an ion can induce in a super saturated environment to create a micron sized droplet with an ion as its seed.* Our approach has the potential to measure molecules one at a time by using each molecule as the site for growth of a droplet. The resulting droplet, which contains one analyte species, can then be detected with a commercial particle counting apparatus or any other light scattering approach remotely located. We call this approach **Ion Nucleation Detection (INDe)**. By incorporating this approach into traditional ion-mobility spectrometry (IMS), we expect to improve the sensitivity of the IMS by replacing the widely used Faraday plate sensor with a particle size magnifier (PSM) and a condensation particle counter (CPC).

A system including an atmospheric pressure ion-mobility spectrometer coupled to an electrospray source was developed to generate a steady source of ions of defined size. A first and ultimately second generation ion-magnifier was designed and constructed. The performance of a particle size magnifier (PSM) was tested using electro-sprayed tetra-alkyl ammonium ions and clusters thereof as nanoparticle standards, with diameters in the sub 2 nm range. Subsequent ion-mobility separation generates a continuous source of size selected ions.

The ions were detected by both a Faraday cup electrometer, and the PSM. Inside the PSM, the ion flow was turbulently mixed with a jet of a hot nitrogen flow, saturated with dibutyl phthalate (DBP). This allowed for heterogeneous nucleation of DBP onto the nanoparticles, which grew into droplets.

The performance of the PSM for tetraheptyl ammonium bromide (THAB) is shown in the figure below. The red curve shows the number concentrations of THAB as measured by the electrometer and the blue curve shows the PSM as a function of mobility diameter.

The INDe system is able to track the ion counts with the same precision as the electrometer implying that the concept has been demonstrated. With our current configuration, we find we lose sensitivity to detection to ~1.24 nm, while our target molecule, TNT is ~ 0.75 nm. To decrease the lower size limit and increase concentration sensitivity will require a redesign of the PSM. Currently, a new PSM is being tested that should improve the turbulent mixing rate and thus the separation between homogeneous and heterogeneous nucleation zones, such that we can operate at higher supersaturation ratios. We plan to investigate other working fluids besides DBP, which is currently used.



Contract Performance

Health Monitoring of Energetics

Sensing of Strain in Energetics

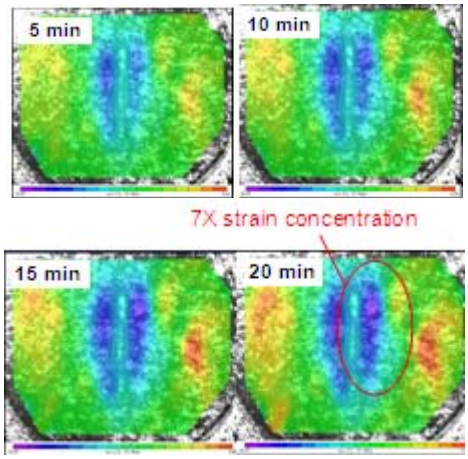
We have developed a technique for sensing strain in energetics, using Digital Image Correlation (DIC) to track a speckle pattern with a video camera in order to obtain the 2-D deformation fields that characterize strain such as those that develop during curing/aging of a polymer. In the DIC technique, a deformed image is correlated with a reference image to determine the displacement fields associated with the change in position of a subset of the image, typically an area of 100 pixels by 100 pixels. Numerous subsets are correlated over the entire area of interest in the image in order to obtain a displacement field. 2-D splines are then fit to the displacement fields in order to obtain strain fields, typically using an area of 51 data points around each displacement location.

Characterization of Simulants

Sample tested was a highly filled propellant stimulant known as “Polycrete”, which had approximately 88 wt. % solids loading, similar to a propellant. The polymeric binder for Polycrete is a fast-curing, two-part elastomer, similar in mechanical behavior to a propellant binder, and consisted of a mixture of filler sizes ranging uniformly from 50 microns to approximately 2 mm. For the speckling pattern, a combination of white spray paint, solid particles, and aluminum specks were used. From the strain results obtained from DIC over the first hour for this sample, it became apparent that there were trends which were not physically consistent with the curing behavior. For example, the average shear strain was significantly higher than the normal strains. However, almost all of the strains were nearly negligible (less than 100 microstrain) compared to the base polymer. This indicates that there is significant constraint from the filler phase on the polymer curing, and subsequently very high stress development that can lead to faster deterioration and defect development due to aging.

Integrated Sensors

Hard electronic components for sensors have also been integrated into polymers to understand the effect of the sensor on the evolution of strain during curing and during operation of the electronic component. The electronic component was placed in the polymer prior to solidification. The evolution of the strain fields near the electronic component is shown below using DIC contour plots of transverse strain. These results can be used to resolve the strain concentration near the embedded component due to its constraint on the deformation of the polymer, which is about 7X that of the matrix and can lead to premature debonding. Thus, it may be necessary to encapsulate the component in a material, such as a softer polymer, that may reduce the strain concentration due to the constraint of the electronic component. It has also been possible to measure the effects of operating the electronic component and model it with thermomechanical Finite Element Analysis (FEA). Results have indicated that there are very rapid increases in temperature and strain within the polymer adjacent to the electronic component. The axial strains appear to be far less significant than the transverse, which indicates that the component will debond from the polymer and fail to accurately monitor the health of the energetic if the interfacial strength is not adequate. Thus, this technique will serve as a tool for developing appropriate embedded sensor technology.



Contract Performance

Virtual Training Studio

We have developed a personal virtual environment (PVE)-based virtual assembly system called Virtual Training Studio (VTS). The current system focuses mainly on the cognitive aspects (e.g., ability to recognize the correct part, to correctly orient the part in space, remembering the right assembly sequence). The PVE consists of a head mounted stereo display with head tracking and a wand for user interaction. This PVE gives the user a complete 3D immersive experience during virtual assembly. The VTS aims to improve existing training methods through the use of a virtual environment-based multi-media training infrastructure that allows users to learn using different modes of instruction presentation while focusing mainly on cognitive aspects of training.

The Virtual Training Studio is a suite of tools, which currently consists of the Virtual Author, Virtual Workspace, and Virtual Mentor. With Virtual Training Studio, training instructors have the option of employing multi-media options such as 3D animations, videos, text, audio, and interactive simulations to create multi-media training instructions. The virtual environment enables trainees to practice training instructions, using interactive simulation and hence reduces the need for practicing with physical components.

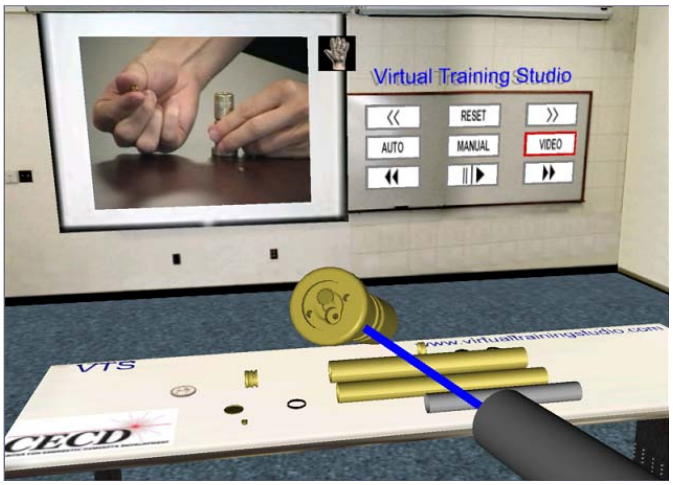
Training

Trainers and trainees interact with the system, using a Head-Mounted Display (HMD) and a wireless wand. Four optical trackers (infrared cameras) and two gyroscopes are used to track the position and orientation of the user's head and the wand. The wand consists of an off-the-shelf wireless presenter, an infrared LED, and a wireless gyroscope. Inside the virtual reality environment, the user can manipulate the CAD models and the buttons using a virtual laser pointer, which is controlled by the wireless wand. A wireless gyroscope and another infrared LED are mounted on the HMD. The cameras track the two LEDs to determine position. Trainees interact with a component of the VTS called Virtual Workspace. The goal of this component of the VTS is to provide the basic infrastructure for multimodal training. Virtual Workspace offers three primary modes of training: (1) 3D Animation Mode which allows users to view the entire assembly via animations, (2) Interactive Simulation Mode, which is a fully user driven mode that allows users to manually perform the assembly tasks, and (3) Video Mode, which allows users to view the entire assembly via video clips.

The Virtual Mentor module simulates the classical master-apprentice training model by monitoring the actions of the user in the Virtual Workspace and assisting the user at appropriate times to enhance the trainee's understanding of the assembly/disassembly process. The Virtual Author enables the instructor to quickly create multi-media training instructions for use in the Virtual Workspace without writing any code.

Performance

System performance was assessed using thirty subjects and two tutorials. The first study involved a rocket motor and 94 percent steps were performed correctly by the users during the physical demonstration after completing the training. In the second study, using a model airplane engine, 97 percent steps were performed correctly.



Contract Performance

Shock Wave and Detonics Research

This is a multi-task program in support of research activities in energetics at NSWCIH. The main research focus is to explore with NSWCIH scientists how electromagnetic fields can change sensitivity and performance of explosives. Additional scientific support was provided by reviewing proposals, scientific papers, attending scientific and program review meetings, mentoring young scientists, and providing training classes in shock and detonation physics.

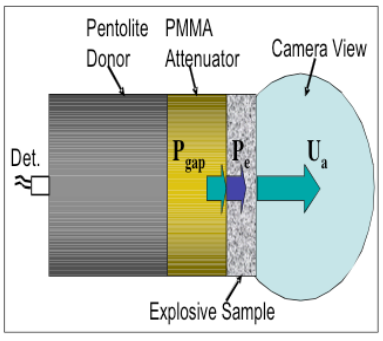
The modified gap shock sensitivity test is being used to see if electric fields change the sensitivity of HMX compositions with concentrations by mass 92% and 88%. This task is in collaboration with Dr. Richard Lee at NSWCIH. One composition was cast cured and the other pressed. The surface velocities of shocked explosive samples (see figure) were measured with and without electric fields, using a high-speed digital-camera.

Velocity versus input pressure plots give shock sensitivity thresholds for first reaction, deflagration, and detonation. The data showed higher levels of reaction when a modest field was applied for the cast cured explosive. The data for the pressed explosive displayed too much variance with and without fields applied to determine any effect. As part of the overall research project, three junior scientists were mentored.

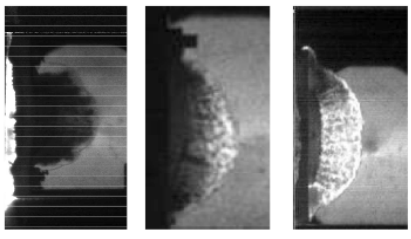
A number of specialized education/training exercises in shock wave and detonation physics were conducted. These were:

- A series of lectures on shock wave and detonation physics was provided for summer interns and Post-docs at NSWCIH. A 6-week course on shock wave thermodynamics of condensed matter was also provided to NSWCIH research staff.
- A three-day workshop was given at ARL on shockwave and detonation physics. The workshop was recognized by ARL via a letter of commendation for its technical breadth and depth.
- Two lectures were given on “Detonation Physics Grand Challenges” at the Research and Engineering Education Facility (REEF) campus of University of Florida. This campus supports Eglin Air Force Base in energetics research activities.

Modified Gap Test*



Single frames from three different experiments with different input pressures



6.2 GPa 7.2 GPa 10.3 GPa

*Slide courtesy of Richard Lee NSWC-IH

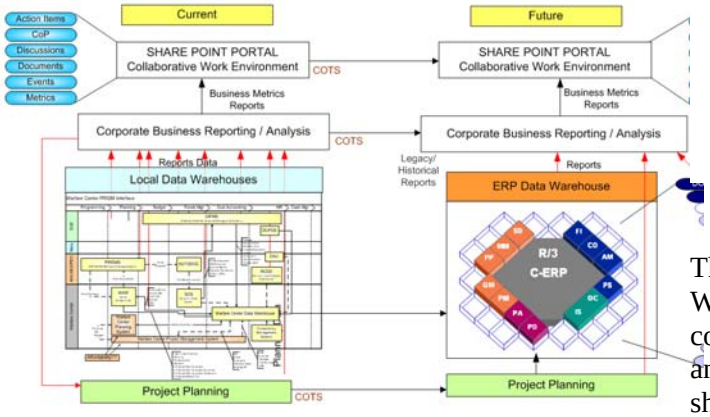
Contract Performance

Support of NSWC Business and Information Technology Integration

This support focuses on Naval Surface Warfare Center (WARCEN) and Naval Sea Systems Command (NAVSEA) business and information technology processes and systems.

The first task supports the development of the WARCEN Enterprise Architecture (EA) roadmap and ensuring alignment to NAVSEA EA initiatives. EA encompasses defined business processes; supporting standardized software applications; the validation, storage, and integration of the data generated; and finally the systems and networks (business and technical) upon which they operate. This includes both business and technical information technology (RDTE) systems.

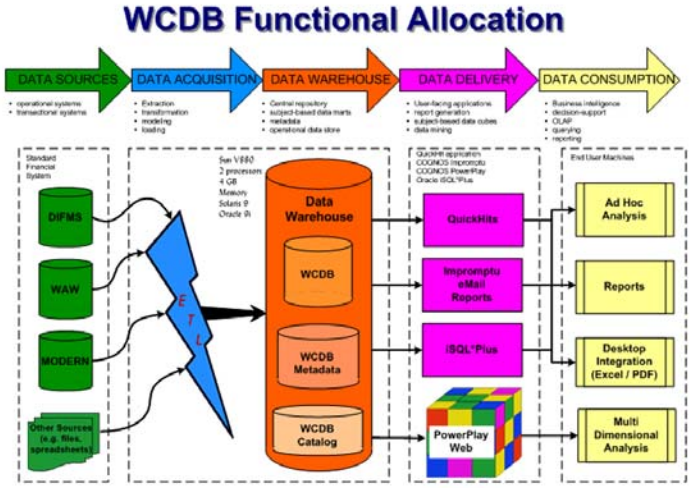
We are working with all the NAVSEA and WARCEN CIO, EA, Business Process, and ERP (Enterprise Resource Planning) executives and their designated leads to develop the roadmap of the "as-is" systems footprint to the "to-be" post ERP foot-print which will occur in 2012-2013.



The second task supports the migration of the WARCEN to the ERP system. This will replace a majority of existing WARCEN business systems. It will not touch the technical systems and networks.

The second task (ERP) is a subset of the first (EA), in that the ERP will fit into "to-be" developed EA and be hosted upon the Next Generation (N-GEN) network which will replace the existing Navy/Marine Corps Intranet (NMCI) IT system. This entails working with WARCEN ERP-lead and CIO on N-GEN and consolidated WARCEN SharePoint/Collaboration Portal. This will be completed in 2009 and will follow the model for standardized system integration.

We have helped develop a data model for automating the WARCEN Technical Health Assessment Process, utilizing existing WARCEN business system. Pilot deployment will be in mid-2009.



The third task supports NSWCIH migration to the WARCEN Corporate Database. This task will be completed in 2009. This will involve developing and training the Indian Head user community and shutting down and archiving their existing legacy systems. ETC staff is actively engaged in transitioning this system to NSWCIH.

Contract Performance

Science, Technology, Engineering, and Mathematics (STEM) Outreach

The past decade has seen both a decline in interest and achievement among American students in mathematics and science. This is happening against a background of the looming retirement of the Baby Boomer generation of scientists and engineers who came of age during the Cold War and Apollo Program. This bleak reality threatens to have a disastrous impact on the spirit of innovation and creativity that has fuelled economic growth and prosperity and maintained our edge in national security against real and potential enemies.

The first challenge is to grow STEM literacy among all students so they can make informed judgments in the face of an increasingly complex world grappling with issues such as stem cell research, global climate change, and data-mining and privacy. The second challenge is to create a talent pool of US citizens capable of working in science and engineering fields. These students must be nurtured and encouraged to pursue rigorous courses of study in STEM subjects and challenged through problem-based instruction, mentoring programs, and enrichment activities to seek degrees and employment in these areas. The ETC can contribute to these efforts.

The ETC is in a unique position to provide support for efforts to refresh, revitalize, and recapitalize the Navy's scientific and technical workforce. Our staff of experts from both academia and the energetics field has over 100 years experience as well as well-established connections to the educational and technical communities.

As a tangible first step in our endeavor to grow the future workforce, the ETC has provided over $500,000 in STEM scholarships and related activities to the College of Southern Maryland, as well as assisted educators in shaping future curricula specific to energetics related degrees and certificates. In 2008, the first cohort of 22 students from Charles, St. Mary's, and Calvert counties was formed. Each of these students is pursuing an Associates Degree in a STEM field and has been paired with a mentor from their chosen field of study. The cohort model includes social interaction and peer support as well. The ETC is also working to provide employment opportunities for students in this program.

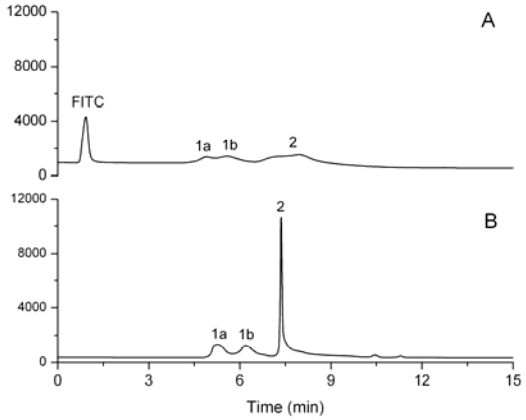
In 2009, the ETC will leverage our experience and knowledge in the fields of education, STEM initiatives, workforce development, and contracting to provide expertise and contract vehicles for executing National Defense Education Program, the Navy's 21st Century Engagement, Engineering, and Technology Program and other DoD educational outreach efforts; to furnish summer interns who address the Navy's diversity objectives; to create an assessment framework for outreach efforts; and to create a way to bring practitioners of STEM outreach efforts together to collaborate, share, and coordinate their activities.

Contract Performance

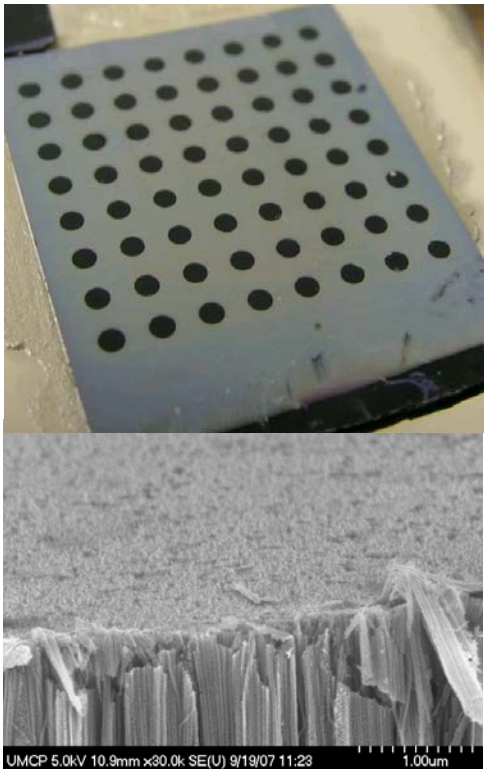
Laser Desorption/Ionization Mass Spectrometry for Trace Explosives Detection

A novel matrix-free laser desorption/ionization mass spectrometry (LDI-MS) platform has been developed based on nanofilament silicon (nSi) substrates. The technology overcomes key limitations of existing LDI-MS systems for trace explosives detection by enabling increased surface/analyte binding, improved contaminant removal, enhanced ionization at low laser powers for higher sensitivity detection, and on-target sample concentration. While optimization of the technology is ongoing, proof-of-concept has been demonstrated with detection of nitroaromatic and nitramine-based energetic materials well below the current limit of other emerging platforms such as desorption/ionization (DESI).

While our initial efforts have primarily been focused on demonstrating the nanofilament silicon fabrication process and leveraging a proprietary electrowetting methodology to achieve efficient adsorption of purified sample on the nSi surfaces, commercial application of the technology will require compatibility with "dirty" samples acquired from a variety of sources. Preparing the sample for nSi-MS demands the removal of particulates and fractionation to isolate the target molecules to the greatest degree possible without sacrificing detection sensitivity. To this end, we are developing a disposable microfluidic sample collection cartridge, combining multi-stage filtration of particulate matter, solid-phase extraction of low molecular weight species on the basis of both differential hydrophobicity and ion exchange properties, buffer exchange to bring the sample to the optimal pH for nSi-MS sensitivity optimization, and final deposition onto an integrated nSi chip within the microfluidic system. The cartridge will only require a user to add a sample volume in dry or solvated form to a loading reservoir, followed by manual pressure actuation of on-chip buffers and solvents to drive the sample preparation and deposition process. The result will be a sample loaded onto the nSi substrate ready for LDI-MS analysis. The combination of the nanofilament silicon and microfluidic sample preparation is expected to position the resulting technology at the forefront of presently-available commercial trace explosives detection platforms.



Demonstration of sample cleanup and concentration using on-chip monolithic solid phase extraction column



Nanofilament silicon array chip (top) and electron micrograph of the nanofilament surface (bottom)

Contract Performance

Business Case Study of NSWCIH

This study was conducted under the leadership of RADM (ret) Millard Firebaugh as part of our ongoing policy and strategic analysis efforts. The study was of NSWCIH, analyzing its role in the Navy and DoD, as a Center of Excellence in Energetics.

The study goal was to provide an analysis of NSWCIH that would serve as a basis for a plan to enhance its value as a critical resource to the Navy, DoD, and the nation. The business of NSWCIH was assessed and actions are recommended to ensure that this vital technical capability endures. In any business case analysis, a compelling question to be addressed is the future of the market for the goods and services being provided by the business. In this case, the study included an "outward" look at the future of energetics for the DoD and the role of NSWCIH in realizing that future, and then an "inward" look at the conduct of the energetics business at NSWCIH.

Major Recommendations

Put forward and drive to implementation an aggressive RDT&E plan for the future of energetics and create leadership advocacy at the highest levels of the DoD and DON.

Create a strategic human capital management program that aligns the workforce to achievement of the new mission.

Reduce manufacturing capacity to only that needed to enable the rapid movement of any energetics product from concept through prototyping.

Close all excess facilities.

Satisfy NSWCIH electric power needs directly from the grid and eliminate the need for centrally produced environmental and process steam.

Develop a formal business development strategy/ process for more selectively targeting new work opportunities.

Develop a strategy for systematically placing NSWCIH personnel in key fleet/program office positions.

Study Team Members

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Indian Head Division Representatives

Dr. Robert Gates
Mr. Adam Nave
Ms. Lois Bohne, Study Executive Secretary

Continuing Activity

Developing a compelling argument for the "Future of Energetics" in order to obtain advocacy from DoD for investment in energetic research, development, and manufacturing technology and to ensure equally critical energetic science and technology expertise to meet future national security requirements.

Business Development

Mild Traumatic Brain Injury - Helmet Material

The Mild Traumatic Brain Injury (*MTBI*) Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine has defined *MTBI* as traumatically induced physiological disruption of brain function manifested by at least one of the following: i) any period of loss of consciousness; ii) any loss of memory for events immediately before or after the accident; iii) any alteration in mental state at the time of the accident. We have formed a group consisting of engineers and scientists from the CECD, the ETC, and the Medical School in Baltimore to study this with the view of redesigning helmets that would mitigate the effects on the brain.

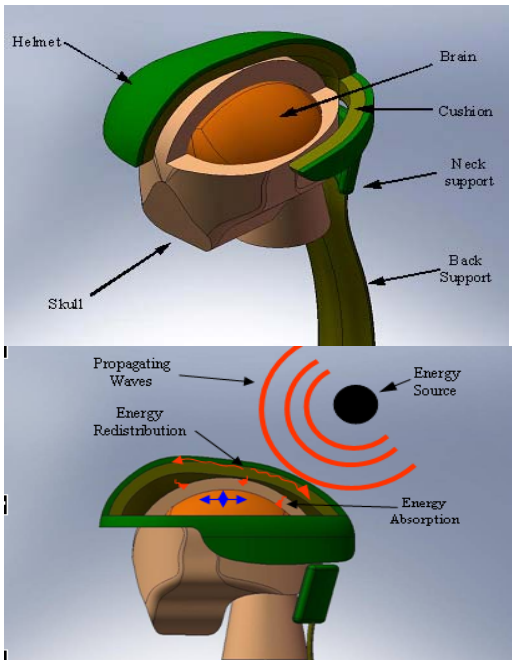
State of the Art

Pellman *et al*. (2006) investigated the performance of new NFL helmets under impact. It was shown that newer design improved the absorption of impact energy during normal conditions in a football match. However, better designs are still needed to overcome what is called the elite impact condition, normally at speeds above 11.2 m/s. Sensors have been implemented to measure real time impacts during college football matches. The collected data may help understand when concussions occur. Accelerometers have been used as sensors in these studies.

Continuing Studies

Our group is studying these issues in an effort to address gaps and questions, which include the following:

- Standard criteria used for establishing injury criteria consider only the motion of the center of mass of the head. Injury criteria are formulated as empirical relationships that depend on the acceleration of the head. While there is much discussion about the relative importance of linear acceleration versus angular acceleration in causing a brain injury, the approach suffers from the fundamental shortcoming that the relative motion of the brain with respect to the skull is not taken into account. Furthermore, despite the brain being a highly deformable entity, brain deformations are not taken into account in the models.
- While finite element models point to coup pressure and shear strain as failure criteria and also show that the use of helmets reduces the pressure and shear stress on the skull elements, they offer little insight into the actual mechanism of energy transfer to the brain as a result of impacts on the skull.
- A system approach could be useful in formulating the problem.
- Recent experimental work based on MRI methods has provided in vivo strain measurements on the brain. These results point to the importance of developing injury criteria that are based on brain deformation. Helmets could be designed as energy absorbing and redistributing mechanisms in the energy path to the brain (see figure).
- Perhaps a helmet with a harness should be considered to reduce the translational acceleration levels experienced by the brain (see figure).



Business Development

Energetic Data Warehouse

Design

There is a pressing national need to assemble a repository of information and databases affiliated with energetic materials and related information, including a list of regionally located cadre of energetics experts for providing real-time insight in the case of an energetics event.

The data warehouses conceptually are a computer-based information systems that are home for "secondhand" data that originated from either another application or from an external system or source. Warehouses optimize database query and reporting tools because of their ability to analyze data, often from disparate databases and in interesting ways. They are a way for users to extract information quickly and easily in order to answer critical questions. These systems are read-only, integrated databases designed to answer comparative and "what if" questions. Unlike operational databases that are set up to handle transactions and that are kept up to date as of the last transaction, data warehouses are analytical, subject-oriented, and are structured to aggregate transactions as a snapshot in time.

The Warehouse

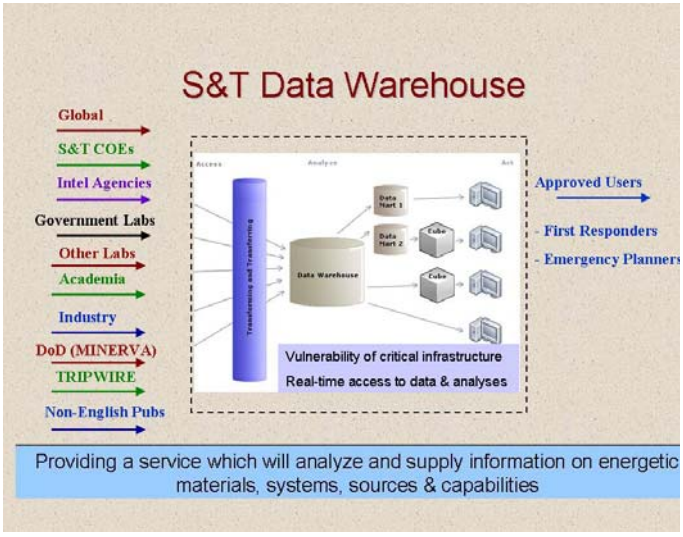
The data warehouse shown for our application will serve as a *resource* (energetic-related knowledge management (KM) system).

The warehouse will:

- focus on providing a valuable user experience by improving information access, enhancing the quality of decisions, and promoting cross-functional integration.
- integrate commercial off-the-shelf compo-nents.
- collect energetic-related information from validated sources on a regular basis and integrate it with geographic information system (GIS) data sets.
- establish data-models and integrate the validated information into a time-stamped energetic-related picture.
- ensure that the data is properly safe-guarded, validated, and maintained.

The system will focus on scalability (growth), security (user and system safeguards), timely delivery of information (bandwidth), and ease of use (must be seen as a value-added). The repository of information will have COTS front-end, ad hoc query capability to enable analyses by a subject matter expert (SME), web-portal promoting first responder and emergency planner teaming, collaboration, streaming-news analyses, and sharing of lessons learned.

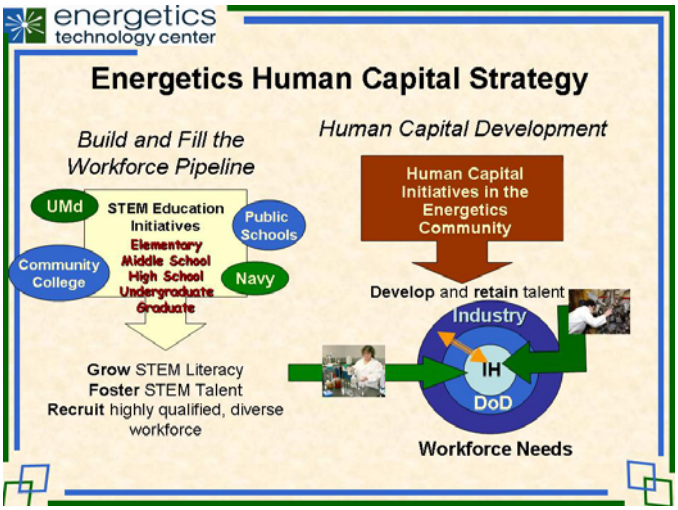
It is our goal to satisfy overall user requirements by utilizing existing data sets as much as possible. The data in a data warehouse should be reasonably current, but not necessarily up to the minute, although developments in the data warehouse industry have made frequent and incremental data dumps more feasible.



Business Development

Energetics Human Capital Strategy

We have begun to formulate a coherent strategy to address current and future workforce issues facing the energetics community. While the initial focus of our efforts is on NSWCIH and the State of Maryland, our efforts have the promise of addressing broader scientific and technical workforce issues across the Department of Defense.



The first element of our strategy is to put in place appropriate human capital development plans and processes to ensure developing and retaining talent, and preserving critical knowledge in support of the Indian Head Division Business Strategic Initiative:

"Hiring, shaping, developing, and diversifying the workforce…ensure we have the right number of people with the right skill sets at the right time…ensure that IHDIV/NSWC can effectively reshape and redeploy its people to meet the workload demands..."

Toward this overarching goal, in 2008, the ETC interviewed a cross section of NSWCIH employees (including technicians, engineers, and supervisors) and members of the contractor community to gather general information on the strengths and weaknesses of current human resources functions and workforce needs. In 2009, based upon information gathered, we propose to be fully engaged with NSWCIH leadership in developing all the elements of a human capital strategy and plan.

One of the key elements of that plan will be focused on capturing expert knowledge, and transferring that knowledge to next-generation energetics staff. The Navy, like the rest of the Department of Defense, is facing a looming loss of experienced workers from the baby boom generation, who will transition to retirement in the next five to ten years. This problem has been exacerbated by a failure to invest in the technical workforce in recent years. Indeed, the Secretary of the Navy recently warned that a "*combination of personnel reductions and reduced RDT&E has seriously eroded the Department's domain knowledge and produced an over-reliance on contractors to perform core in-house technical functions. This environment has led to outsourcing of 'hands-on' work that is needed in-house, to acquire the Nation's best science and engineering talent and to equip them to meet the challenges of the future Navy. In short, it interferes with the Department's ability to control its own technical destiny." (Donald C. Winter, Memo dated 10 October 2008, Subj: Department of the Navy Acquisition).*

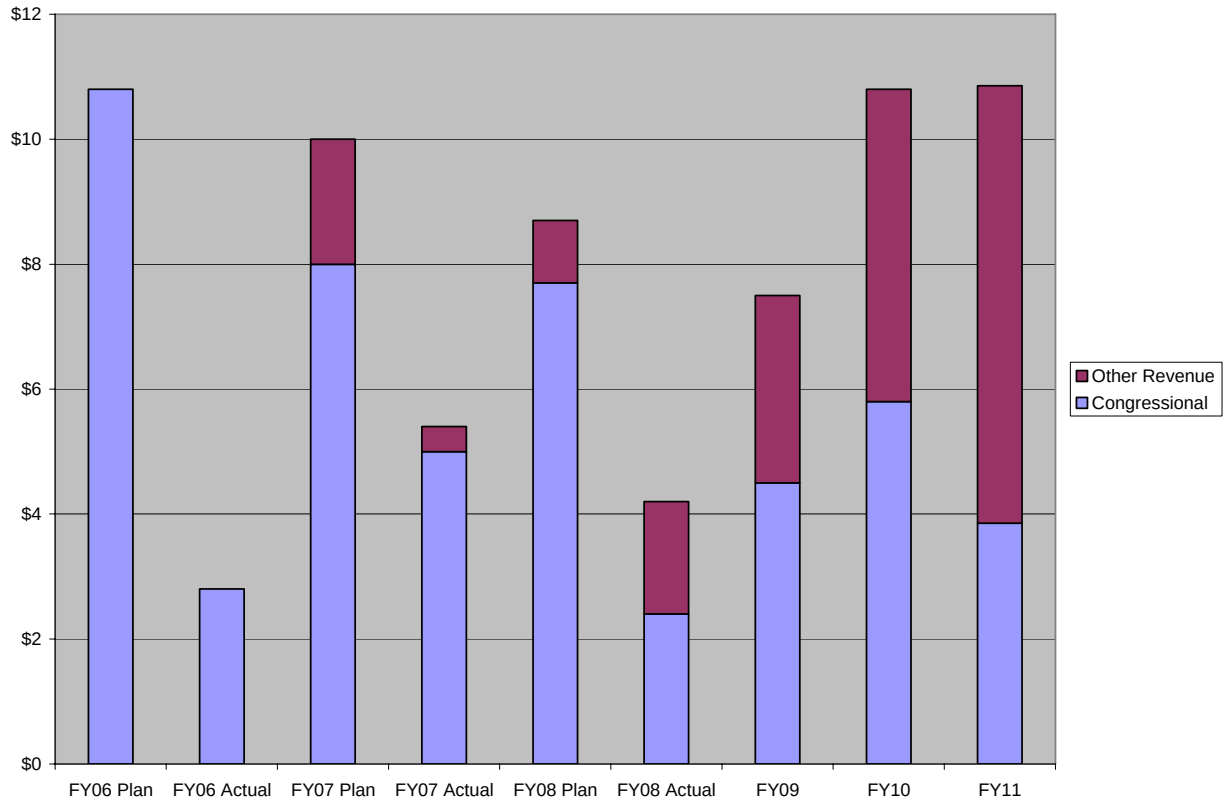
NSWCIH offers a microcosm of this situation. 44 percent of the current workforce is over 49 years old. These employees gained an invaluable amount of experience during the Cold War and are applying that irreplaceable knowledge in the Global War on Terror. Our challenge is to put in place processes and systems for knowledge retention before they retire. We must act quickly to ensure that we retain necessary technical knowledge within our laboratories and combat centers. We plan to work closely with NSWCIH to do just that.

Revenues

The main goal of technical and workforce development-related efforts is to execute a program that is of critical import to the Navy. Specific objectives are: 1) to grow and expand core CECD research thrusts; 2) to initiate ETC technology development projects that result in additional revenue coming into the ETC; and 3) build a long-term technical foundation that is recognized as an important part of the national security infrastructure.

A number of strategic planning discussions have been held between CECD/ETC and NSWCIH leadership to ascertain how best to utilize funding for the long-term benefit of the energetics community, and the leadership role envisioned for NSWCIH and its CECD/ETC partner. These discussions will continue to shape our business plans in the future.

Of particular note is that in 2008 revenues of $1.8M were realized through projects funded by NSWCIH, ONR, and NSWCDL.



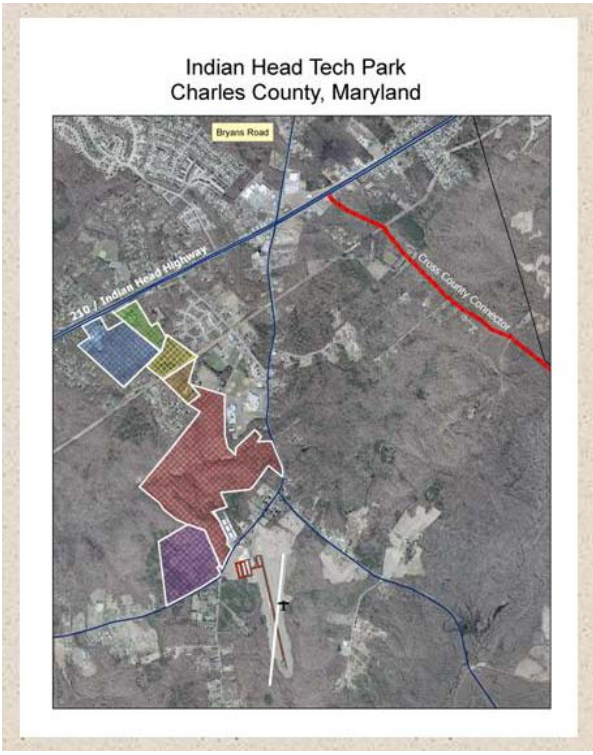
CECD/ETC Revenues

The Indian Head Science and Technology Park

Charles County has selected a team consisting of the Corporate Office Properties Trust (COPT) and the Facchina Group of Companies, LLC, to design and develop the Science and Technology Park. The team has secured nearly 300 acres of property, which provides direct access to Maryland Routes 210 and 224. The first tenant, Martin Baker UK, has been signed while other large DoD contractors and one major hotel chain plan to participate in the occupancy of the Park. The ETC will be an anchor tenant in this park.

The CECD/ETC team has developed the conceptual design requirements for a 50,000 square foot building in the new proposed Technology Park, now officially titled the Indian Head Science and Technology Park, on Route 210 which will house the ETC, its close collaborators, and tenants. NSWCIH facilities and laboratory capability will not be replicated in this effort. A Leadership in Energy and Environmental Design (LEED) Silver certification level for the building was originally part of the conceptual design and is now a baseline requirement by the developers of the Park for any facility occupying the Indian Head Science and Technology Park.

Charles County has also committed to fund infrastructure development, including sewer and water, high-speed internet access, and four-lane highway access to support the Indian Head Science and Technology Park and the ETC.



Energetics Research, Education, and National Security

The capability of a nation's ordnance systems is fundamental to whether a war is won or lost. Thus, "ordnance on target" is a fundamental end goal and mission of every combat system in existence. Once the ordnance gets to the target, it must carry out its purpose accurately, reliably, and predictably with unwavering repetition. In World War II, impact to destroy a bridge, or similar target, took literally thousands of sorties, and collateral damage was extensive and a "given".

Beginning with the Vietnam War, high technology began to be integrated into ordnance. By the time Desert Storm occurred, our tanks were equipped with shells that were highly accurate, with a standoff distance twice that of the enemy. In addition, the "gun propellant" in the shells, called "gunpowder" prior to that time, was of a high technology design incorporating "insensitivity", meaning that the shells were less likely to explode in a tank's storage compartment if an enemy shell hit the tank. Increased insensitivity leads to enhanced survivability, increasing our battlefield advantage.

Today, virtually all larger ordnance items are replete with high technology provided by materials and electronics. The propellants and explosives in modern weaponry are designed in a detailed scientific fashion using advanced, specialized, highly protected chemical knowledge. Some formulations are so intricate that they must be mixed horizontally instead of vertically, or they will explode. Others have the opposite characteristic and must be mixed vertically. Knowing the difference requires years of expertise and highly trained chemists, physicists, and engineers.

Electronics and complex chemical formulations will be packaged together in high tech ordnance for the foreseeable future. Once again, the capability to provide these critically needed, extremely effective, high technology, integrated explosive/electronic weapons is inherently dependent upon a workforce of trained, experienced, dedicated, and knowledgeable people, working on advancing the science and application of energetics, something that is threatened today.

The critical mass of our ordnance development workforce is now being threatened by a large number of impending retirements, coupled with the lack of an in-place mechanism to evolve new scientists and engineers in the ordnance technology field. The mitigation of this is a key goal of the CECD/ETC Enterprise.

The national security benefits of the Southern Maryland Initiative fall into a variety of categories. The Initiative enables the country to maintain an ordnance technology edge; heighten national security; improve warfighting effectiveness; produce commercial applications; enhance our national position for technological international competitiveness; provide a pool of talent for industry; and create a knowledge feed stream for a broad range of related high technology areas.

Our Initiative will create a pool of technology, knowledge, and individuals, which will enhance our national position for technological international competitiveness. As with all fields of

technology, advancements in knowledge and capability will have a spin-off into other related fields. The advancements in the fundamental sciences of explosives, propellants, and electronics will naturally provide spin-off applications that will become benign civilian products in the international marketplace. This US-based Initiative will allow the products to be American-based, thus creating American jobs. Employment is an element of national security.

Concurrently, the initiative will provide a pool of talent for industry and create a knowledge feed stream for a broad range of related high technology areas. Both of these things are inherent elements of improved national security. As the ordnance industry ages, it, too, will need to rejuvenate its workforce with appropriate talent. The initiative will provide a comprehensive function to create the solution to this need. Not all individuals trained and experienced through the Initiative are expected to remain in Southern Maryland. It is a natural event in our society that individuals seek to better themselves, and the Center will provide a ready pool of talent to be recruited at the time that industry needs them. This, combined with the continual feed stream of ordnance knowledge produced in the Center, will strengthen and enhance our national security.

The CECD/ETC Enterprise clearly provides significant and substantial benefits for our national security.

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The CECD/ETC Enterprise Growing Science & Technology in Southern Maryland

…Design, Simulate, Visualize in Global & Virtual Environments