The Southern Maryland Initiative for Energetics Capability Development

Annual Report

January 20, 2012

www.cecd.umd.edu
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Foreword

The CECD/ETC team, working with NSWCIH, ONR, ARL, 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.

This *Annual Report FY12* provides an overview of accomplishments, ongoing activities, and future plans of the CECD/ETC Enterprise in Southern Maryland. It is the eighth in a series of documents for the *Southern Maryland Initiative for Energetics Capability Development: A Response to Emerging National Needs.*

The United States Congress has provided funds in the past 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 growing a strong presence in this field and, in partnership with NSWCIH, establishing a world class Center of Excellence in Energetics.

Davinder K. Anand
Professor and Director
CECD

Robert A. Kavetsky
Executive Director
ETC

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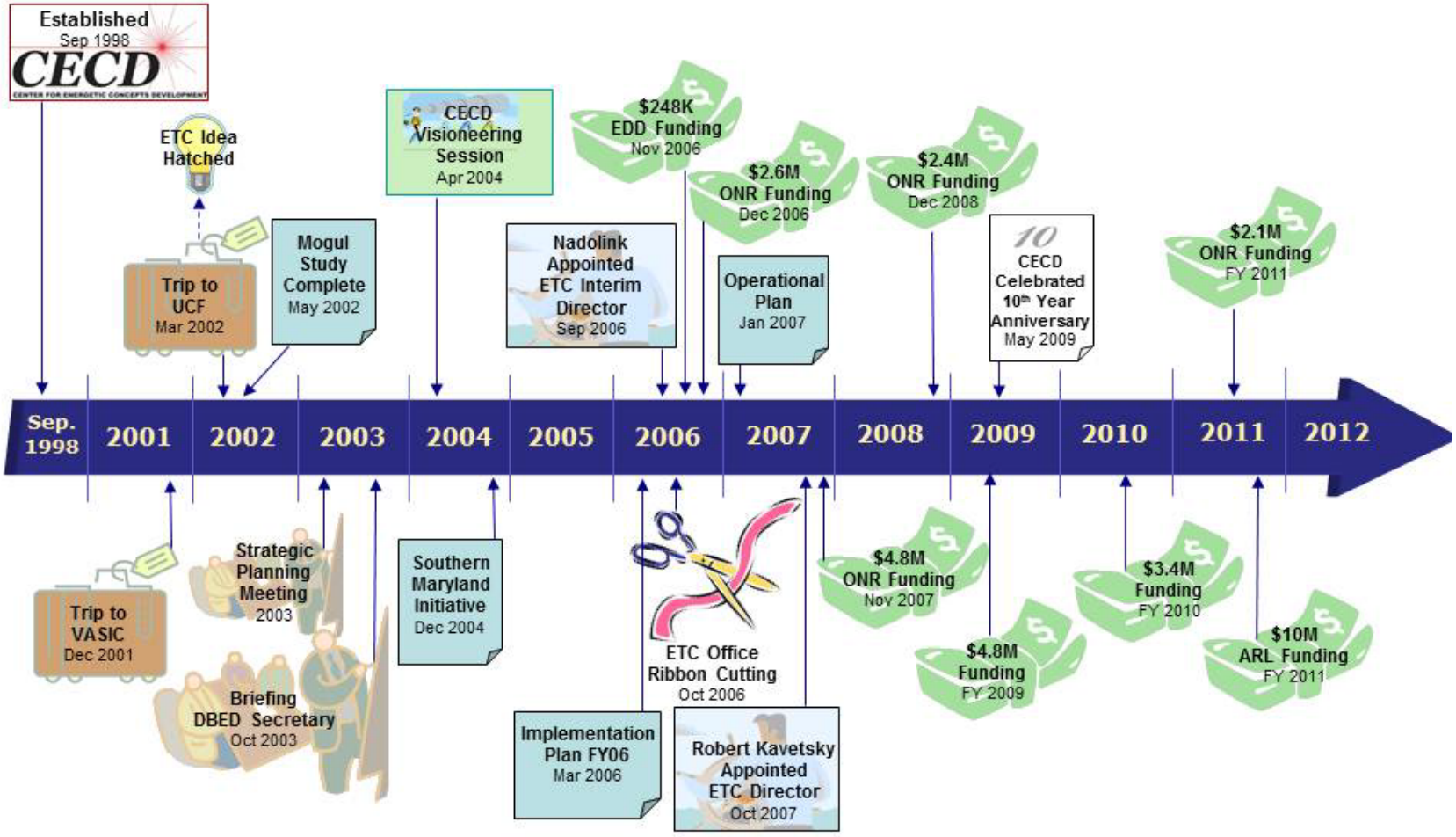
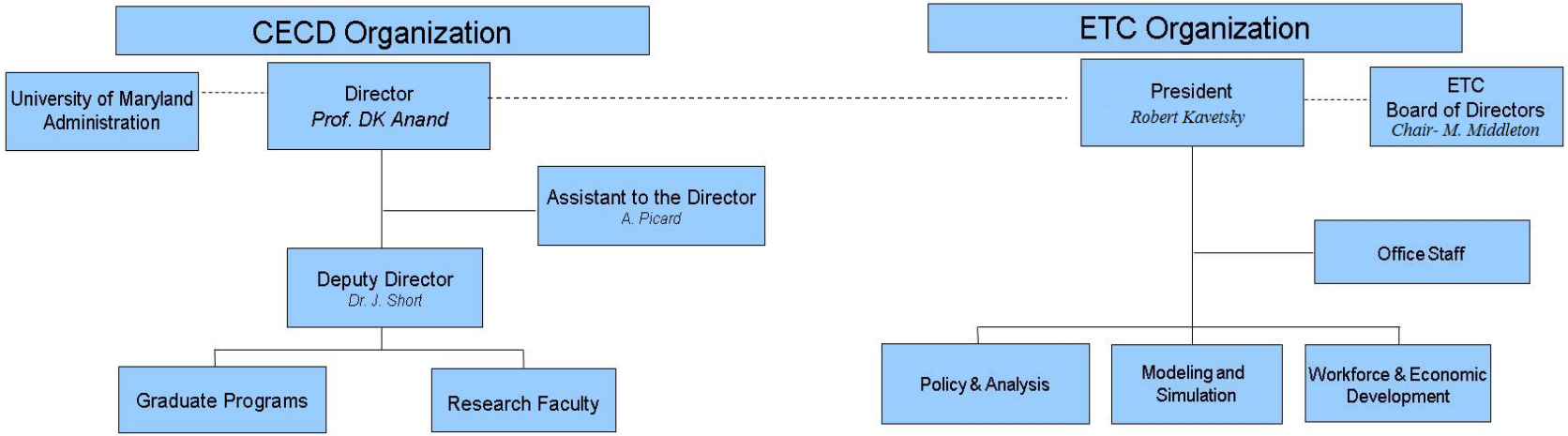
Growth of the CECD/ETC Enterprise



CECD/ETC Enterprise

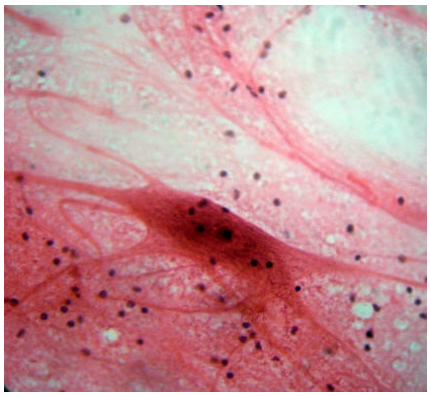


Contract Performance

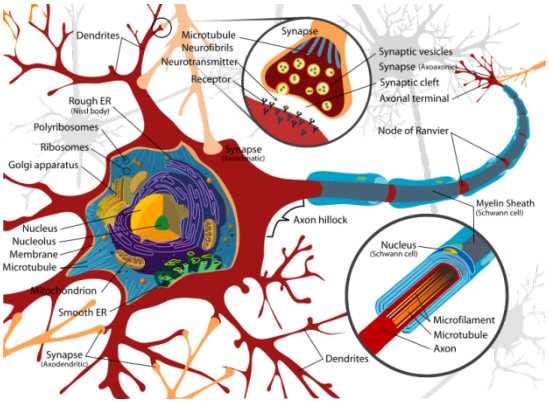
Soft Tissue Associated Wave Phenomena with Application to Brain Injury

Biomaterials are usually classified as hard tissues (bone, wood) and soft tissues (skin, muscles, organs). Brain tissue is characterized as a soft tissue and it is composed of what is called nerve tissue, that is to say, a network of neurons or nerve cells. The figures below show two images of nerve tissue in which structures can be clearly discerned. These structures are neurons, which are composed of a relatively large body, with multiple extensions called dendrites, and a single elongated extension (rod-like) structure called axon. Other smaller cells that act as a support for the neurons are the glial cells (whose nuclei can be observed as black spots).

This work investigates wave propagation in soft tissue in order to carry out the following: i) understand the influence of soft tissue nonlinear material properties on its mechanical response when subjected to transient loading and ii) characterize the mechanical response of soft tissue with respect to the frequency and amplitude of the applied loading.



Nerve Tissue



Neuron Detail with Myelinated Axon

The linear analysis is used to study the effects of blast waves on the internal structure of the human brain. Axons can be thought of as rod-like structures whose lengths in the brain range from 10 mm to 170 mm, or even shorter. By using this analysis, the frequency bound for propagation of waves through axons of different lengths can be obtained.

This linear analysis has allowed us to understand wave characteristics such as wave speed and attenuation. Further studies were conducted via numerical solutions of the nonlinear problem. One unique nonlinear phenomenon that can be of potential importance, and that cannot be predicted by linear analyses is the steepening of wave fronts, leading to abrupt changes in stress as the wave travels; this behavior resembles features associated with shock waves.

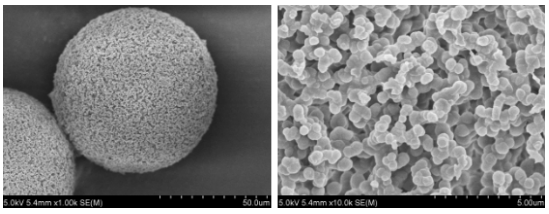
We conclude that the rod model for brain fibers allows us to understand the importance of nonlinear material properties and the importance of considering the nonlinear nature of these properties, especially, for blast load related problems. It is also noted that the transient response of the nonlinear material is highly influenced by the amplitude of the load, the frequency components of the load and the dissipation of the soft tissue. Therefore, accurate determination of the material properties of soft tissue is crucial in developing models that can accurately capture transient nonlinear effects.

Contract Performance

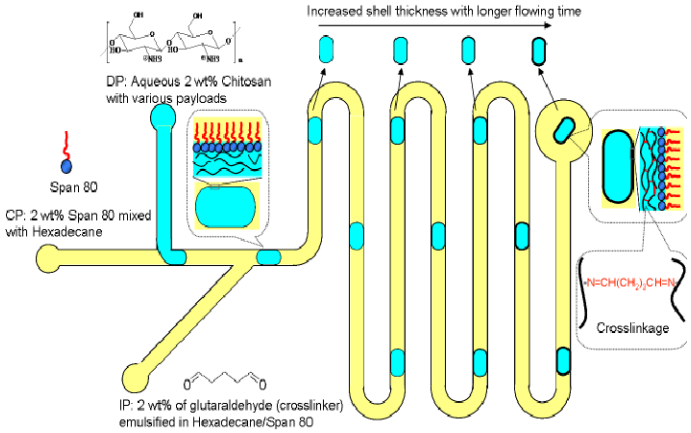
Nanotechnologies for Trace Explosives Detection

This research thrust has focused on the development of novel nanotechnology-enabled platforms for trace gas-phase explosive detection. Due to the concentration gap between the vapor pressure associated with trace amounts of explosives and the sensitivity limits of established detection modalities, there remains a strong need for new technologies enabling the effective detection of trace explosives. As part of our overall efforts to realize novel materials for label-free and real-time trace explosive detection, we are developing a new porous microparticle technology with the aim of achieving concentration factors of 104-105, at least 2 orders of magnitude higher than established technologies and enabling trace analysis with parts per quadrillion (ppq) detection limits, making the technology suitable for the detection of buried munitions vapor.

Initial project efforts focused on the developing of functionalized nanoporous materials as novel surfaces for ultrasensitive analysis of adsorbed explosives by surface-enhanced Raman spectroscopy (SERS). Three specific material systems were explored in this effort: macroporous polymer monoliths, nanofilament silicon dioxide, and microporous anodic alumina. While initial efforts such as the microporous alumina sensor were successful at demonstrating picomole-level sensitivity for common explosives, including TNT and RDX using SERS readout, the technology required detection from the liquid phase, necessitating cumbersome sample introduction into a solvent before deposition on the alumina surface.



SEM Micrograph of a 70 µm GMA Polymer Monolith Microsphere (left), and Details of the Porous Structure (right).



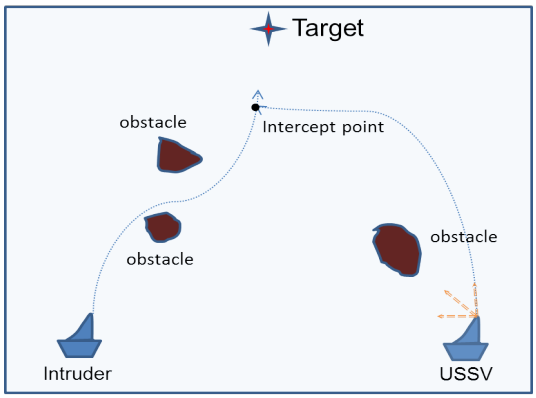
Schematic of a Microfluidic Technique for the Synthesis of Monodisperse Particles

We have successfully demonstrated sensitive gas-phase TNT detection, using a single 60 µm diameter nanoparticle-functionalized microbead coupled with a simple optical detector. A bead was placed in a vial with approximately 0.5 g of TNT allowing the bead to adsorb TNT from the equilibrium vapor pressure within the vial before measuring the Raman shift. The resulting measurement revealed a distinct and repeatable band at 1359 cm-1 with a signal-to-noise ratio above 200. Performance of the sensor beads is attributed to enhanced mass loading resulting from the highly porous structures, with the multiscale flow paths between and within the beads ensuring rapid diffusion of explosive vapor into the structures for efficient sample concentration. Testing under controlled conditions to determine ultimate detection limits and adsorption times are ongoing, together with the characterization of other explosive compounds.

Contract Performance

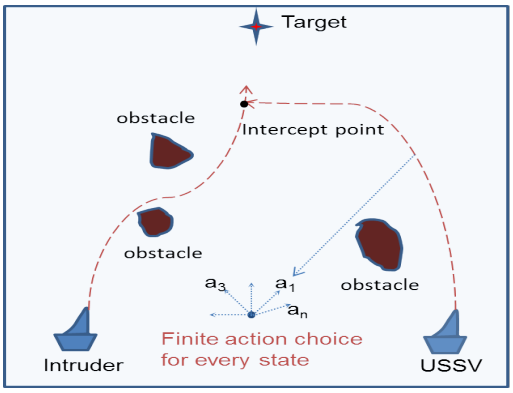
Optimal Routing Strategies for Interception in USSV-Intruder System

The problem where an Unmanned Sea Surface Vehicle (USSV) is protected from an Intruder vessel in unknown environments by designing online strategies for intercepting are studied. It is assumed that the USSV does not have knowledge of the intruder's future action, value function to be optimized, and the environment parameters. The mission was to assign an optimal trajectory for the USSV so that it can intercept the Intruder in minimum time. The focus of the project was on designing online control strategies for the USSV so that it would be able to intercept the Intruder independent of the time-varying control policies, and in unknown environments.



The Interception Problem

The original problem was considerably complicated to solve due to the continuous nature of the state, and the action space. To simplify the problem, it was assumed that the state space is two dimensional, and that the USSV/Intruder moved with constant speed. The desired action was then the optimal moving direction at every state of the two dimensional grid. The absence of sensor uncertainty was also assumed in the proposed formulation for the sake of simplicity. We also adopted a discrete time model for the overall system. The action choices (directions to move) at every state were chosen to be finite. Hence, the system was simplified to a finite state, finite action, discrete time problem.



The Simplified Interception Problem

After a critical survey on different methods, Approximate Dynamic Programming (ADP) was selected to obtain the optimal policy for the USSV system. The ADP methodology was chosen as it can be utilized for solving complex optimal control without knowledge of the precise system dynamics.

It was assumed that the underlying dynamical system can be approximated as a Markov Decision Process (MDP). The transition probability matrix for the USSV system is usually not known precisely. In this situation, the Q function is utilized instead of the value function for deciding the optimal control policy. The ADP algorithm was applied to the USSV system. It was able to approximate the real Q function, and update the policy online.

In the USSV-Intruder system, the goal of USSV is to minimize the time to intercept the Intruder, and the goal of Intruder is to maximize the time to meet the USSV. We simulated selected samples and compared the resulting reward to decide the best action and update the policy. While initial results in this direction appear promising, the primary drawback is that information about the methodology for choosing the best action is known by both players, and hence a distributed solution to the Fictitious Play problem needs to be developed.

Contract Performance

The Dynamic Effects Laboratory

This laboratory has been supported over the period of the last five years to enhance our understanding of pressure time profiles that vehicles are subjected to when a buried mine detonates and mitigation of underbelly blast effects.

We used small scale simulated vehicle models and subjected them to a given set of blast conditions. We used saturated sand as out test beds and the vehicles were approximately 14 inches by 16 inches in extent. All simulated vehicles were subjected to the detonation of the same size buried charge (4.4 gm) with the same stand-off distance from the sand surface to the bottom of the vehicle.

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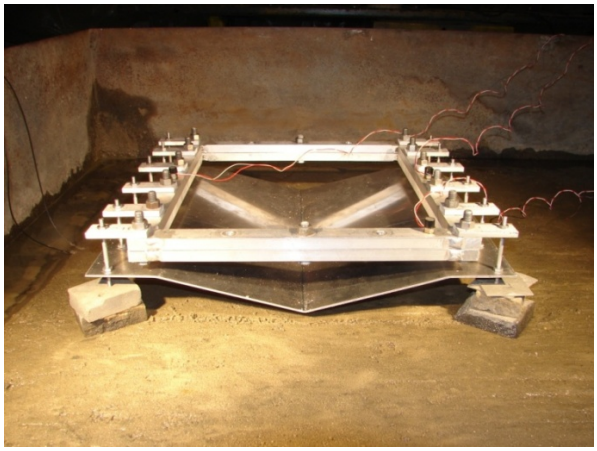


In the tests, we varied the details of the simulated vehicle (manufacture of the frame and hull, polyuria coating, method of attachment of hull to frame, etc.) and determined, using high speed photography and attached accelerometers, the acceleration, HIC, and jerk levels felt on the frame of the vehicles.

We utilized small scale testing to determine the pressure time profiles acting on plates subjected to underbelly detonations. After conducting a large number of tests (approximately 100 tests), we determined that at any given point on the plate the pressures were not reproducible. However, the pressure at any given point over a large number of tests is predictable within a certain margin. The purpose of this exercise was to determine if the applied pressures obeyed a normal distribution.

It appears that the cumulative distributions of peak pressures can be adequately represented by cumulative normal distributions. For the sets of test conditions considered, the normalized pressure distributions from a range of radii are so similar that they can be grouped. It appears that the normalized peak pressures on the target can be arrayed in two groups that correlate with the local loading mechanism. These loading mechanisms are (1) the soil cap over the explosive hitting the target and (2) material from the crater hitting the target as the crater is being excavated. Over the range of HoT examined, the standard deviations of the normalized pressures increase with an increase in HoT for the radii, where the first mechanism dominates, and the standard deviations of the normalized pressures over the radii, where the second mechanism dominates, are quite insensitive to HoT. The complete results from this study can be found in "Pressures on Targets From Buried Explosions", L. C. Taylor, W. L. Fourney, & H. U. Leiste, *Blasting and Fragmentation*, Vol 4, #3, December 2010, pp 163-192.

Contract Performance

Automated Synthesis of Reactive Behaviors for Autonomous Unmanned Vehicles

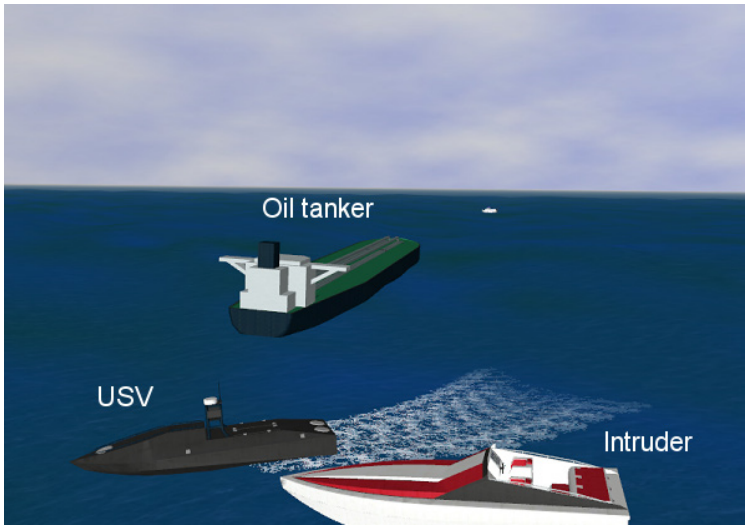
Autonomous unmanned vehicles operating on complex terrains in unstructured environments utilize a combination of deliberative and reactive planning. The reactive layer receives tasks from the deliberative layer and autonomously executes the assigned tasks by monitoring the environment, using sensors and sending commands to controllers to carry out the tasks. The reactive layer is designed to respond quickly and safely to changes in the environment or the physical layer. To ensure fast reaction, the reactive layer must provide real-time computation and execution guarantees. Reactive layers in most planning architectures utilize a library of behaviors that can compute vehicle actions quickly for a given state.

Behaviors implicitly or explicitly use an action-selection policy to decide what actions to take in a given state.

Keeping the design of reactive action selection policies tractable requires us to partition the state space into cells. Actions in a state space cell can be determined using the meta-action attached to the cell.

We have also developed a virtual environment-based visualization system which serves as an emulator of the real USSV environment and contains gaming logic which allows human players to play against each other or against the computer. In the game, the player controlling the intruder boat must reach a protected target, while the player controlling the USSV must block and delay the intruder as long as possible. The game logic is responsible for the rules of the game, game logging and replay, boat behaviors, and scoring. The game can be played on two computers over a network. In addition to offering basic gaming capabilities, the visualization system provides collision detection and basic physics to the objects in the scene.

Deployment of autonomous USSVs in critical missions requires that the performance of the autonomous system matches with that of a remote controlled vehicle. We have used the virtual environment based game to compare the automatically discovered decision trees, representing the blocking behavior to the manually coded behavior. The performance of synthesized behavior matches the performance of manually coded behavior.



Virtual Environment for Simulating USSV

Contract Performance

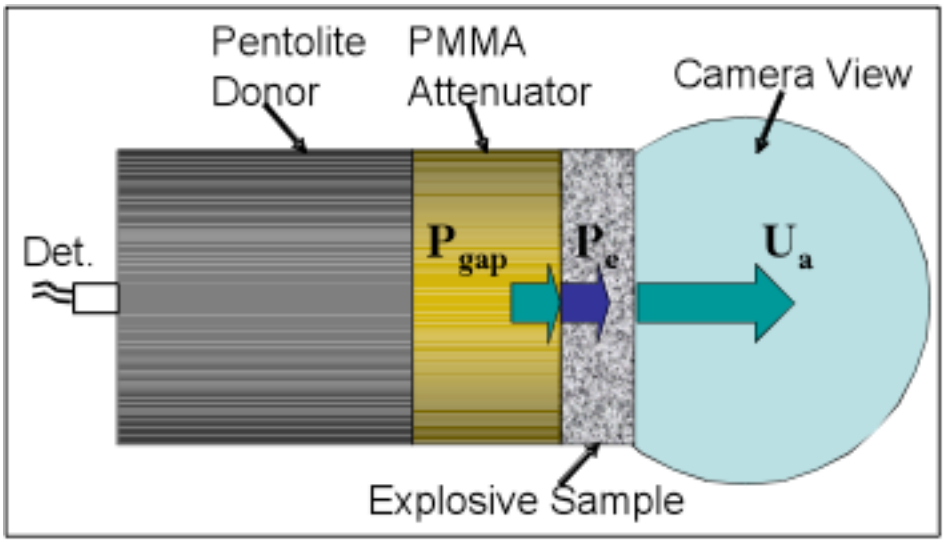
Energetic Material Research

In order to computer model the performance of an explosive in various pieces of hardware, an equation of state (EOS) for the explosive material is needed. One of the more commonly used equations of state is the JWL EOS, which can be obtained from a Cylinder Expansion (CYLEX) Test. In this test, a precisely made copper tube is filled with explosive. Once detonated, a streak camera records the diameter of the expanding tube as a function of time. The streak camera film is then digitized, which allows for the diameter of the expanding cylinder to be obtained and used to calculate the JWL EOS of the explosive, using custom software.

Three CYLEX Tests were performed by NSWC-IH in 2011 and then analyzed by ETC. NSWC-IH was given the resulting JWL EOS parameters, excel files containing data analysis and digital film records for all three tests. In addition, the data analysis software developed at ETC was installed on research computers at NSWC-IH and three NSWC-IH employees were trained in its use along with the techniques used in scanning the streak camera films and obtaining the tube expansion data from the scans.

ETC assisted the NSWC-IH Agent Defeat Program with scheduling, organizing, data acquisition and reduction. Assistance was also given to the NSWC-IH reactive material program by way of reactive fragmentation catching and size distribution analysis.

ETC participated in the design of the research plan of the shocked Aluminum/water project. They provided the unreacted Pressure-particle velocity (P-u) curve for the mixture, using a mixture law that requires pressure and kinetic energy equilibration. This P-u Hugoniot was needed to determine the inert free surface velocity as a function of pressure of this mixture when shocked in the extended gap test experiments. The degree of reaction is measured by the amount of free surface velocity in excess of the inert value. ETC assisted in the drafting of a Indian Head Technical Report that will be published in 2012. This report is titled "Explosive Reaction of Aluminum and Water," IHTR 3234, by Richard Granholm, Richard Lee, Christopher Boswell, Gerrit Sutherland, Thomas McGrath, and Jerry Forbes.



Expanded Modified Gap Test

Contract Performance

Support for STEM Development

ETC provides technical and engineering support to the ASD(R&E) SDO for workforce modeling, data analysis, assessment and evaluation, and program prosecution. During calendar year 2011, we accomplished the following activities in support of SDO and ASD(R&E):

- Completed initial analysis and design for a comprehensive DoD STEM workforce model
- Established a database to track DoD STEM investments and calculate return on investment (ROI) for building and sustaining the DoD STEM workforce
- Developed innovative approaches to build and sustain the DoD system engineering workforce
- Developed comprehensive taxonomies for DoD STEM fields of study and occupations to shape the present and future technical workforces
- Organized a major National Academies study of DoD's current and future technical workforce needs and the Nation's institutional capacity limitations in meeting those needs
- Organized and led major initiatives at the Service Academies and selected prestigious universities to establish joint autonomous systems and systems engineering programs for graduating seniors
- Represented DoD in the working groups for the White House Office on Science and Technology Policy (OSTP) Federal Committee on STEM (CoSTEM)
- Aided SDO and ASD(R&E) in establishing the DoD STEM Executive Board and its working group
- Developed a comprehensive strategy for SDO STEM pre-kindergarten through high school (PK-12) investments and program participation
- Developed taxonomies and structures to map DoD STEM occupations to the DoD Science and Technology (S&T) Priorities and to emerging fields (e.g., complexity studies).

During the calendar year 2012, ETC will continue to support these programs and initiatives, while developing new and innovative ways to characterize, understand, build, shape, and sustain the DoD technical workforce.

Contract Performance

A Simulation-Framework for Generating Planning Logic for Autonomous Unmanned Ground Vehicles

Currently most unmanned ground vehicles (UGVs) are tele-operated via a human or controlled autonomously with hand-coded software. As UGVs become more commonplace and are expected to operate with greater autonomy in more challenging and sometimes unknown environments, traditional methods of hand-coding the control and behavior logic become very costly for a number of different reasons. Many man-hours are required to craft robust logic, and there is increased probability that a critical mission will fail because of an unforeseen obstacle. The costs involved in rewriting and improving planning logic code for UGVs operating in the real world can be significant.

Working closely with the Simulation-Based System Design Laboratory at the University of Maryland, ETC has successfully shown that a viable alternative to producing vehicle logic by hand is to have the vehicle learn its own behaviors in a high-fidelity physical simulation environment. In the simulation, missions, obstacles, environmental factors, terrain, sensors, and vehicle parameters can all be modified with much greater speed than in the real physical world. Thus, a vehicle can rapidly be re-trained for a change in mission or engineering specifications. Additionally, because the simulation environment also allows vehicles and events to be driven by human operators, experts can verify the accuracy of the simulation, teach behaviors by demonstration, and compete against the machine-controlled vehicle.

The requirements for high simulation performance led the group to use the commercially available Vortex simulation library, developed by CMLabs. On top of Vortex, a customized framework for quickly changing the vehicle and environmental parameters was added.

Integrated with the simulation environment is an architecture for automatically generating software for vehicle operation via various machine learning (ML) techniques and testing it in the environment. A breakthrough in machine learning, developed by the team for these projects, involves combining genetic programming with automated identification and patching of failures to automatically synthesize behaviors encapsulated by decision trees.

The team has successfully demonstrated the use of ML to generate logic comparable to what would be hand-coded by a human programmer for two different behaviors. These behaviors were learned in simulation and the resulting logic was executed on a small RC vehicle modified for autonomous operation.

Continuing work will focus on applying the same techniques and tools to a larger, more capable vehicle platform with more complex behaviors. The pictured vehicle has been acquired and fitted with sensors to enable an autonomous operation. The additional sensors and the increased physical capabilities of the vehicle will allow for a much broader set of possible behaviors to be automated, using the same simulation and machine learning framework created for the past platform. This will serve to demonstrate that the theory behind the autonomous behavior generation can be applied equally well to larger platforms.

Vehicle with Computers, Kinect, and Cameras Mounted

Contract Performance

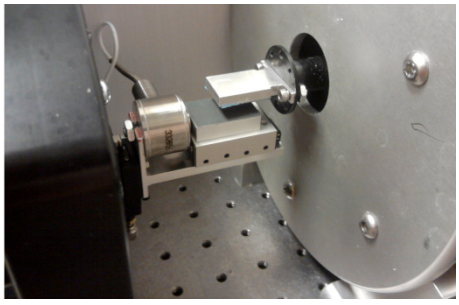
Damage and Solid-Fluid Interactions during Transient Large Deformation of Rat Brain Tissue in mTBI Study

Since rat models have been routinely used for investigating the initial mechanical causes of mTBI, the characterization of mechanical properties of rat brain tissue must be improved. Brain tissue is composed of water and solid phases so that the mechanical properties of rat brain tissue are strongly influenced by the high water content of the tissue and its flow within the tissue under internal pressure induced by a mechanical load.

Confined compression tests, that enforce uniaxial fluid flow, investigate the uniaxial compressive large deformation mechanical response seen in impact injuries and the solid-fluid interaction within the tissue. The experiments aim to elucidate the role of the intercellular fluid between neurons and glia in mTBI. To deal with the small size of a rat brain and to obtain local information, small specimens are excised, especially focusing on tissue surrounding the hippocampus, which other studies have shown to be particularly susceptible to injury. We have shown that compressive loading, such as due to a shock wave, can damage brain tissue at much lower strains than previously reported. At slow and moderate compressive strain rates, the interstitial fluid carries most of the load until the tissue is sufficiently damaged to permit fluid flow. The constant strain rate stress-strain curves at slow and moderate strain rates reach a stress peak at strains lower than 20%, indicating damage, and the peak magnitude shows a statistically significant dependence on strain rate. An increase in permeability corresponds to softening, and an estimate of permeability suggests it depends on strain rate and as well as on strain. In particular, we hypothesize that intercellular fluid flow in the tissue is the immediate cause of tissue damage by rearranging substructures such as axonal tracts as the applied load opens passageways for fluid transport.

Tests that combine compression and translational shear investigate the tissue large deformation response to the longitudinal and shear components of a pressure wave seen in blast injuries. Translational shear is employed because it is a more likely loading of the brain than rotational shear. The interaction of compression and translational shear involves the intercellular fluid carrying load and therefore applying a local force to the solid component of the tissue that can result in damage.

In constant deformation rate tests up to a 40% translational strain with a normal compressive deformation of 20% of the thickness, no damage from the shear deformation is visible externally, but the translational strain versus stress curves indicate internal damage. The tests at constant strain rates of 0.001, 1, and 100/s show a peak similar to that observed in confined compression. Translational strain at the peak is a statistically significant function of rate but the peak stress magnitude is not. The rate-dependence of the strain at which the peak occurs is more likely a response to the shear and may indicate the strain at which shear damage occurs. Again, the shear damage to the solid component allows the internal fluid to redistribute so that it carries lower load at deformations after the peak is reached.



Translational Shear Fixture for 6x6x3 mm Specimens

The Haslach nonlinear viscoelastic (HNV) mathematical model predicts the observed peaks and the coefficients identify appropriate measures of damage. A newly developed unsteady biphasic model, which must also have a damage parameter, is employed to represent the solid-fluid interaction.

Contract Performance

USV Trajectory Planning for Time Varying Motion Goals in an Environment with Obstacles

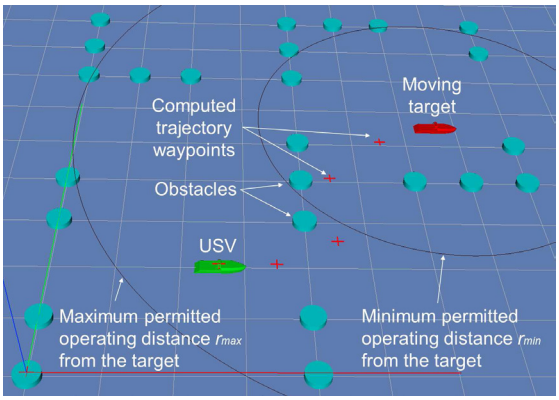
Autonomous Unmanned Surface Vehicles (USVs) have been emerging as an attractive alternative to human-driven boats in a wide variety of missions that require reliable sea navigation. Examples of such missions include harbor patrolling and protecting important assets in vulnerable area, surveillance, environmental monitoring, etc. The USV fulfills its mission through the execution of appropriate behaviors. The behaviors produce motion goals that define the desired locations in the space for the vehicle to reach and planning constraints. Safe, efficient, and reliable following of a time varying motion goal, by the USV in a sea environment with obstacles, is a challenge. The vehicle's tracking capability is inherently influenced by its dynamics, the motion characteristics of the motion goal, as well as by the configuration of obstacles in the marine environment.

The University of Maryland's Simulation-Based System Design Laboratory group has developed an intelligent autonomous system for the USV that includes a lattice-based trajectory planner. The planner efficiently computes a dynamically feasible, resolution optimal, collision-free trajectory to reach a motion goal generated by one or more behaviors. A trajectory following controller for the USV has been utilized to achieve high tracking efficiency while still preserving motion safety. The entire approach is based on the developed USV system architecture that encapsulates the necessary trajectory and behavior planning components. We demonstrate the effectiveness of the developed trajectory planner in a simulated, complex environment with static obstacles.

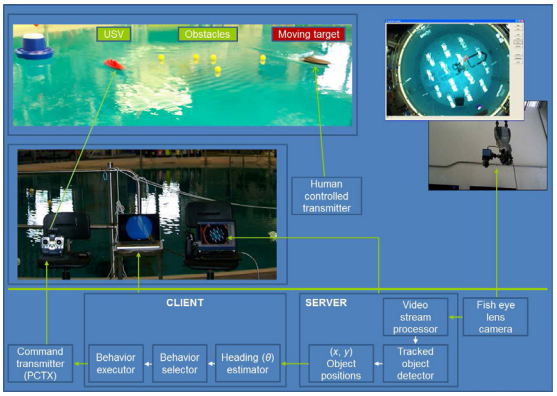
We have developed four behaviors to be able to thoroughly test the planner in different contexts. The developed intelligent behaviors include a follow target boat, rules of the road (COLREGS) crossing, static way point following, and interception behaviors. With the help of the ETC, we have developed a physical evaluation platform to evaluate the performance of the planner in a real environment according to a designed experimental protocol.

The real environment is made up of two RC boats driven in the water tank within the Neutral Buoyancy Research Facility at the University of Maryland College Park. The setup allows us to manually drive one of the boats, using a remote controller while the other boat autonomously follows.

The future plan is to extend the developed trajectory planning approach by a sophisticated motion goal computation technique based on our previous work to be able to make proficient guesses where the target may be within a specified number of planning steps. This will include development of a probabilistic behavior model of the target boat.



Following a Moving Target Amid Obstacles by an Autonomous Unmanned Surface Vehicle

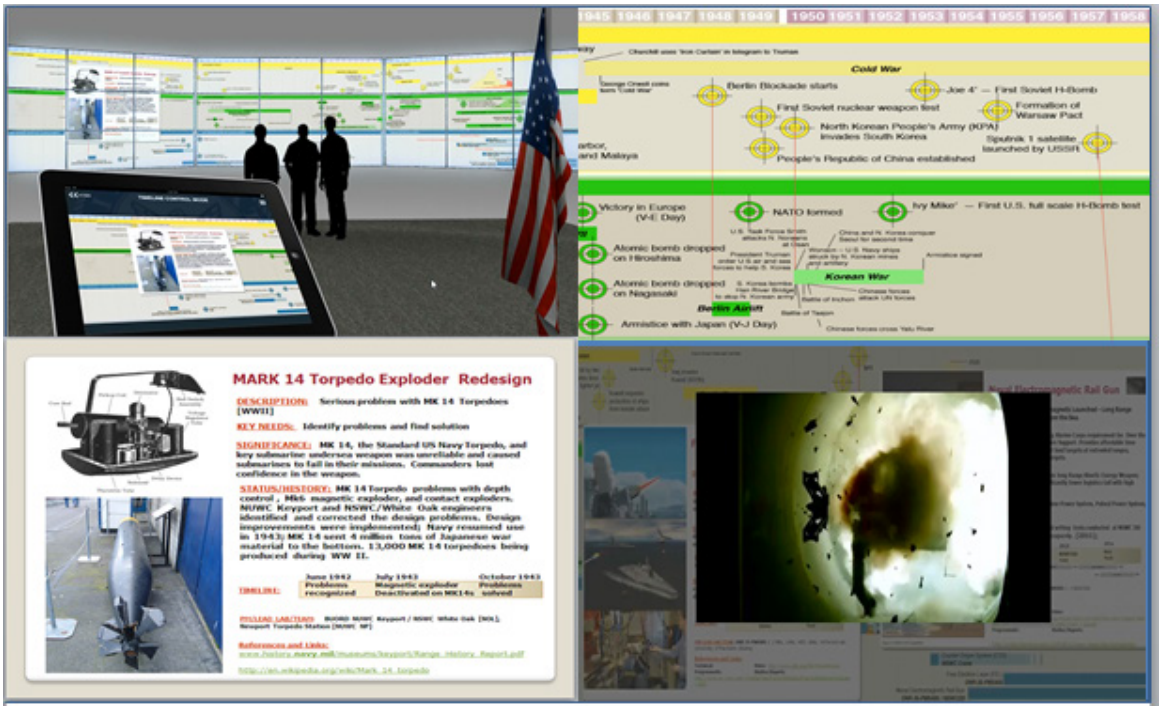


Developed Physical Setup for Testing Autonomous Behaviors in the Neutral Buoyancy Research Facility (NBRF) at the University of Maryland College Park

Contract Performance

Information Center

In 2011, ETC concluded a *Policy and Strategic Planning* task for the ASN Research, Development, and Acquisition (RD&A) Principal Civilian Deputy, oriented at exploring and developing options for a decision support center that would be used for senior DON officials to evaluate and assess personnel, facility and funding information in a timely and consistent fashion. In particular, ETC outlined and provided some details for developing and delivering a flexible and scalable tool for communicating extremely complex information. This tool, in a "War Room" setting would facilitate deep, historically based understanding of past needs, issues, and successful solutions, and most importantly, allow all involved to see a "common operational picture" of the problem space, current RD&A capabilities and gaps, and past and possible future successful solution spaces.



(a) Shows a notional war room/informatics center with timeline displays and a tablet based user interface, (b) Shows expanded details of the timeline associated with the Cold War Korean Conflict, (c) Shows a fact sheet associated with the WWII Mk14 torpedo exploder issue, and (d) Shows a screen capture following activation of a hyperlink to a NSWC Dahlgren Division test of the Naval Rail Gun.

After completing the contracted effort, ETC continued developing the concept with additional illustrations and knowledge collection oriented specifically to the Energetics community. This internal effort is aimed at illustrating how complex technical information can be conveyed as threads or overlays.

ETC is continuing to explore and design means of harvesting, analyzing, and conveying facts and knowledge related to Defense R&D and in particular, Energetics related disciplines, to maintain and facilitate national Energetics related capabilities.

Business Development

The PoWER Center

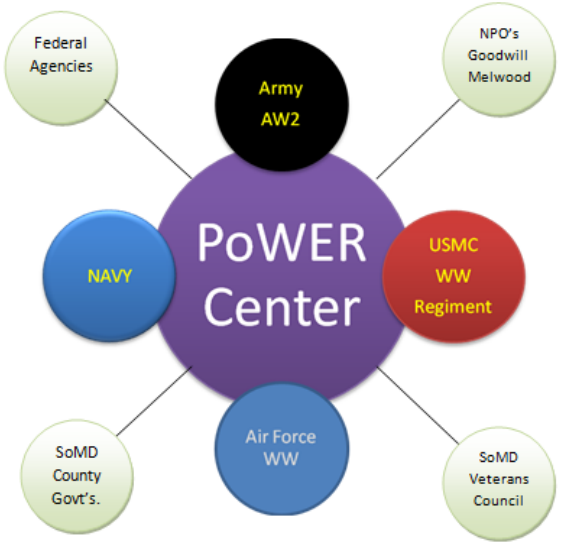
Wounded, ill, and injured veterans of the U.S. military are hindered with several obstacles as they transition into the civilian workforce. These obstacles include medical, educational, and financial duress to name a few. To address these issues, the Crane Technology Institute (CTI) created a pilot program in January of 2008 in partnership with the Naval Surface Warfare Center (NSWC) in Crane, Indiana. Similarly, in 2010, a partnership between Energetics Technology Center (ETC) and the Naval Surface Warfare Center in Indian Head Maryland (NSWC-IHD) brought this highly successful model to the National Capital Region, assigned it a new identity, and the Potomac Workforce Education and Recruitment (PoWER) Center was born. The statistics show as of September 2010, Maryland has upwards of 25,000 veterans from Operations Iraqi/Enduring Freedom, with an overwhelming number of them residing in the Southern Maryland counties.

Recruiting qualified candidates has been achieved by attending Operation Warfighter events at Walter Reed Army Medical Center and Bethesda; attending the hiring events at Camp Lejeune to work with the Marines at the Wounded Warrior Battalion; and finally, finding candidates from the myriad of Wounded Warrior lists distributed by the regional Navy Human Resource Centers, Northrop Grumman, and recently the Navy Yard. Referrals have been a strong recruitment tool as continual referrals are received from the Maryland Department of Labor Licensing Regulation, "Maryland Commitment to Veterans" staff, and clients we have successfully placed.

The PoWER Center has a one page marketing flyer to supplement the pocket card; this allows the ability to showcase our successes for distribution to interested parties. A PoWER Center Facebook fan page has been implemented. PoWER Center clients tend to be younger and more internet savvy, thus this was an obvious cost neutral method of recruiting candidates.

During the period from June 28, 2010 to June 28, 2011, the PoWER Center was able to facilitate seven hires. Currently the PoWER Center has 45 resumes of candidates seeking employment opportunities. All but two of the veteran candidates have service connected disability ratings of 30% or more and are either unemployed, underemployed, or have a significant barrier to employment.

The PoWER Center has networked with Melwood and Goodwill of Greater Washington D.C. These organizations have similar programs in place to serve individuals with disabilities and expressed an interest in partnering with the PoWER Center to employ more wounded, ill, and injured veterans who fall into the category for which they exist. The PoWER Center was able to connect with the Senior Vice President of Military.com, by way of Project Healing Waters Fly Fishing. This will diversify the employment opportunities greatly and with an endorsement from Military.com and the parent company Monster.com, the PoWER Center will be in a better position to maximize exposure to the veteran community.



PoWER Center Partnerships

Business Development

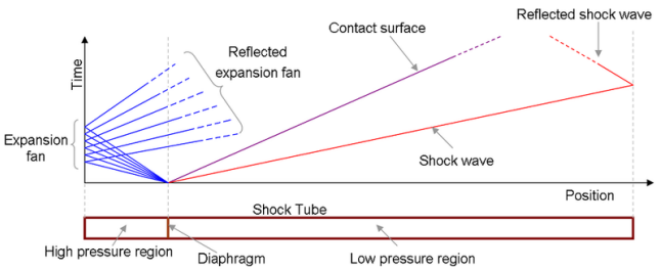
Traumatic Brain Injury, Comparison of Injuries in Shock Tube, Blast Tube and Free Field Experiments

We have proposed a comparative study of shock tube, blast tube and open field blast tests to determine the relevance of the various test results to the blast events actually experienced by soldiers and Marines in combat. Shock tubes, and to a lesser extent blast tubes, of various sizes have been used extensively to simulate open field air blasts to study the effects of blast waves on the brains of small animals. In general, the loading time and the frequency content of the shock wave in the tube do not match those of an open field blast wave. The issue then becomes one of determining whether the injuries imparted to the animals in the two environments are similar and the thresholds for those injuries can be correlated.

A free field explosion creates a shock wave with an abrupt pressure rise followed by a slower decrease in pressure caused by the three dimensional expansion and cooling of the gas behind the shock front. For example, a 15 lb charge of TNT at a distance of 25 ft yields a peak pressure of 6.7 psi and a positive duration of 5.8 msec. Scaling that charge to the size of a small animal (geometric scale factor of 0.1) requires a charge of 0.015 lb (6.8 grams), which yields a blast load of equal peak pressure at the scaled standoff distance of 2.5 ft, but a positive duration of only 0.58 msec.

There is no single design or configuration for the shock tube to be compared with the free field explosion. In general, all have a compression chamber and an expansion chamber separated by a diaphragm which is abruptly broken to initiate the shock wave. Some have multiple compression chambers to provide for tailoring the pulse shape. Some use other than compressed air, usually helium, for the driver gas. The test animals are either positioned internally in the expansion tube or externally downstream of the exit plane of the expansion tube. The idealized operation of the shock tube is shown in the figure on the right. If the low pressure region is closed at the far end, a reflected shock will form. If left open as in the typical bTBI experiment, a complex flow field will form down-stream of the opening. Within the low pressure region, there occurs a step rise in pressure as the shock wave passes a given location followed by a period of near constant pressure and then a slow decrease in pressure as the expansion fan, reflected from the back of the high pressure region, reaches the same given location. If the shock tube is designed such that the expansion fan overtakes the shock wave at some point, then the period of near constant pressure is eliminated and the peak pressure is eroded from there on. The desired peak pressure can be obtained in the shock tube by adjusting the pressure in the high pressure region and the duration can be varied by adjusting the length of the high pressure region. But the positive duration of the shock wave is typically on the order of several milliseconds, much longer than the 0.58 msec of the above free-field example.

The overall objective of the project is to develop a set of bTBI data on small animals from open-air blast tests, determine a bTBI threshold for open-air blast tests, determine if/how the bTBI data from shock/blast correlate to open-air blast tests, and recommend a future direction for conducting shock/blast tube and open-air blast tests. The specific objectives are to determine if the injuries sustained in shock tube experiments can be correlated to those sustained in free-field blast experiments through the loading parameters; i.e. peak pressure, impulse and/or the frequency content of the pressure pulse.



Basic Shock Tube

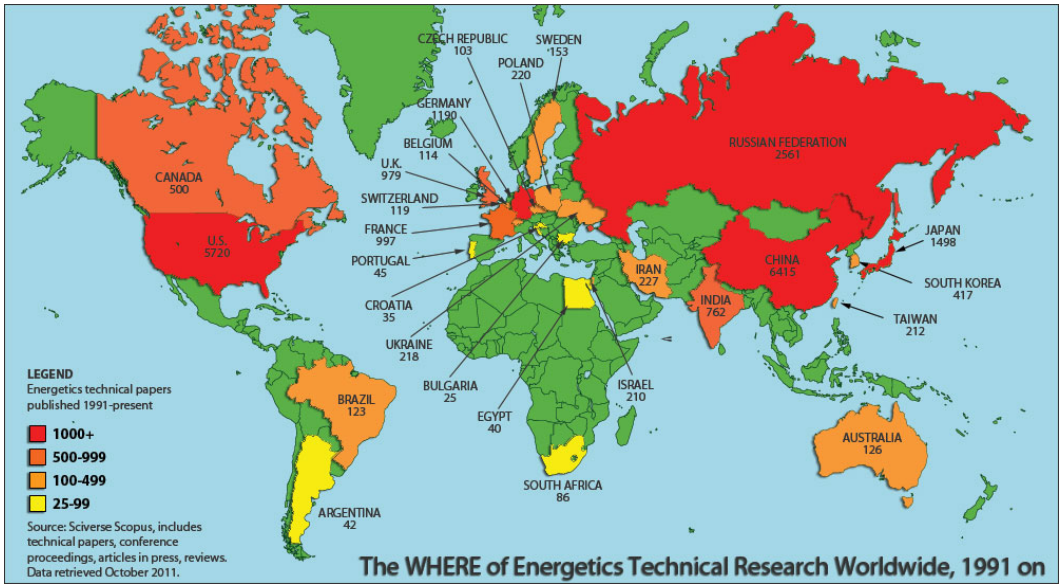
Business Development

Worldwide Energetics Informatics

This project is concerned with a systematic survey and analysis of worldwide energetics research literature. The group is attempting to answer the overall question of "What is the world doing in Energetics?". A bibliometric source analysis was undertaken of available databases of technical research papers. The repository uses RIS as the output format of choice in conjunction with the Papers bibliography software on the OS X platform.

The process of gathering data began with a list of attendees of past NTREM (New Trends in Energetic Materials) conferences, focused mainly in Europe. A strong keyword list was then built following an iterative process, using terms and phrases particular to energetic materials that had appeared in paper titles, keywords and abstracts from an initial seed term collection. This list is currently comprised of 138 keywords, phrases and compounds, and includes 185 carefully crafted exclusion terms in an attempt to narrow the result set, due to the multi-disciplinary nature of the Scopus database.

The resulting keyword list was used to search each country worldwide in an effort to begin to answer the questions of who, what, where, and when of energetic materials research.



World Map Showing Concentration of Energetic Materials Research Output, 1991-2011

Additional analysis work is planned to examine trends within the captured data, using open source bibliographic analysis tools. Citespace, software designed to assist in visualizing and analyzing trends and patterns in scientific literature, is a promising tool, and testing with other common tools has shown the ability to perform reasonably straightforward analysis with this bibliographic data. Future work planned includes the possible development of a system for automated gathering of updated technical papers, an expansion to other data sources, such as Google Scholar, for more time-sensitive data gathering, and additional data types, such as web pages, full-text papers, etc.

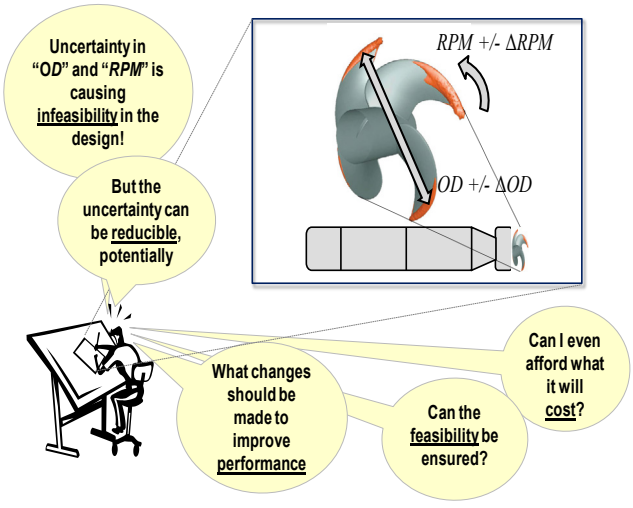
Business Development

Engineering System Selection and Optimization under Uncertainty

The objective of this research was to explore and develop Multi-Attribute Decision Analysis (MADA) and Multi-Objective Robust Optimization (MORO) models and methods for making one or more "best' choices for engineering (including Naval) systems under uncertainty.

A MADA model was developed for a notional case study dealing with payload (rocket) selection for a Fire Scout helicopter. A Fire Scout helicopter is used on Navy ships to defend from attacks by small boats. For the case study, the decision variables considered were the type and quantity of payloads. The conflicting attributes were to minimize the cost and weight of the helicopter payload while maximizing the probability of kill for an unknown number of boats which may be of unknown size. In the MADA model, the three attributes were scaled and weighted to reflect their relative importance and combined into a single value function. Next, an Influence Diagram was devised, using the PrecisionTree® tool, to calculate the 'payoff' of each of the payload alternatives. The influence diagram was used to rapidly explore different choices and compute corresponding payoffs and also facilitate sensitivity analysis and more in-depth assessment of solutions. An alternative approach was also investigated and developed, using the utility analysis theory of MADA, which took into account risk taking behavior of the decision maker during the payload selection. A MORO technique for dealing with reducible and irreducible uncertainty was also investigated and developed.

The work involved offline sampling, meta-modeling of objective and constraint functions and finally a two-level MORO approach that accounted for reducible and irreducible uncertainty for parameters. This approach is able to generate optimized solutions that are comparable to those obtained without approximation and with much less computational effort. For such systems, sometimes, it is feasible to decrease the amount of uncertainty in parameters, of course at a cost, to achieve better performance.



Research Questions Explored for MORO

Energetics Research, Education, and National Security

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.

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. 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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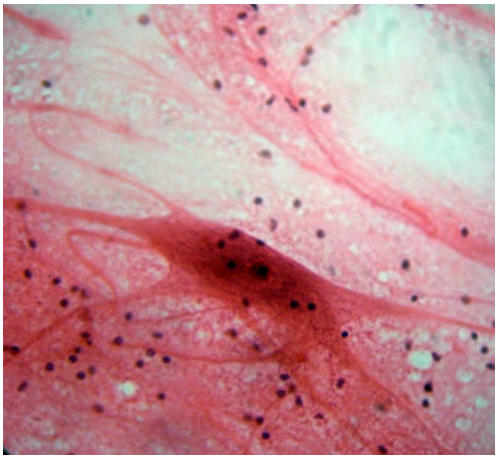
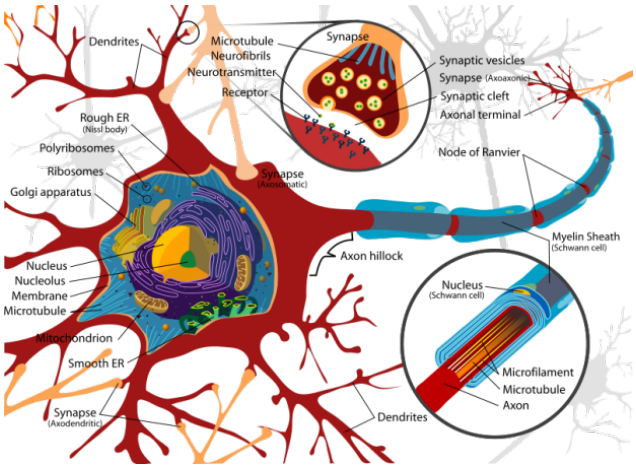


Nerve Tissue



Neuron Detail with Myelinated Axon

A Catalyst for Science and Technology in Southern Maryland