History of the Center for Engineering Concepts Development (CECD)

The formerly-named Center for Energetic Concepts Development (CECD) was established at the University of Maryland, College Park, as a cooperative research activity between the Naval Surface Warfare Center Indian Head Division (NSWC-IHD) and the University of Maryland. In response to a proposal from Professors R. Armstrong, D. K. Anand and W. Fourney, an agreement was signed in 1998 which included research, graduate education, technology transfer, and exchange of technical personnel. The period of performance was five years, and the founding Director was Professor Ronald Armstrong.

Center for Energetics Concepts Development agreement signing ceremony

Upon signing the agreement, NSWC awarded $50K to CALCE and shortly after that in 1999 Professor Armstrong retired and left to go to Eglin Air Force Base, Florida as Senior Scientist in the Munitions Directorate. Professor Davinder K. Anand became the director, and continues to serve as director in 2018. Dr. James Short, who formally worked at NSWC-IHD and then the Office of Naval Research (ONR), became the Deputy Director.

For the next two years small grants came to CECD until the incidents of terrorism in the US on September 11, 2001. A few days after the incident the Office of Naval Intelligence (ONI) awarded $3M to establish a project supporting NSWC and CECD to investigate the safety of harbors. This gave impetus to additional funding from a variety of sources over the next sixteen years. Research support was received from the State of Maryland, the Naval Surface Warfare Center Indian Head Division (NSWC-IHD), the Office of Naval Intelligence (ONI), the Office of Naval Research (ONR), Army Research Laboratory (ARL), Air Force Office of Scientific Research (AFOSR), National Science Foundation (NSF), Department of Housing and Urban Development (HUD), Lawrence Berkeley National Laboratory (LBNL), Los Alamos National Lab (LANL), Arete

Associates, NCI Information Systems, Iktara and Associates and the Sandia National Laboratories (SNL). In addition, we received support from ONR for equipment purchase for a Micro-Electro-Mechanical-Systems MEMS Laboratory in the Department (Professor Don Devoe), and two Young Investigator Awards from ONR (Professors Hugh Bruck and Steven Buckley). All the agreements included a significant cost share from the University of Maryland.

The vision of CECD was to become the preeminent National Center concerned with the science and manufacturing of energetic materials and products for national defense and security, and further, to train the next generation of scientists and engineers working in energetics through its graduate educational and research programs. Research in Energetics comprised not only the traditional work in formulations, but manufacturing and packaging of the energetic material, as well. This included the entire gamut of engineering, design, test and evaluation, prototyping, and in some cases, manufacture of the product itself. At Indian Head this ranged from large packages to small cartridge actuated and propellant actuated (CAD/PAD) like devices. CECD faculty and students were engaged in a number of these activities, which included: Energetics materials, Functionally Graded Materials, MEMS Components and Packaging, Nano Particles and Systems, Design Knowledge Archiving and Retrieval, Lean Manufacturing, Optimization and Design, Data Mining and Informatics, Combustion Systems, Port Safety, and Visualization in Virtual Environments.

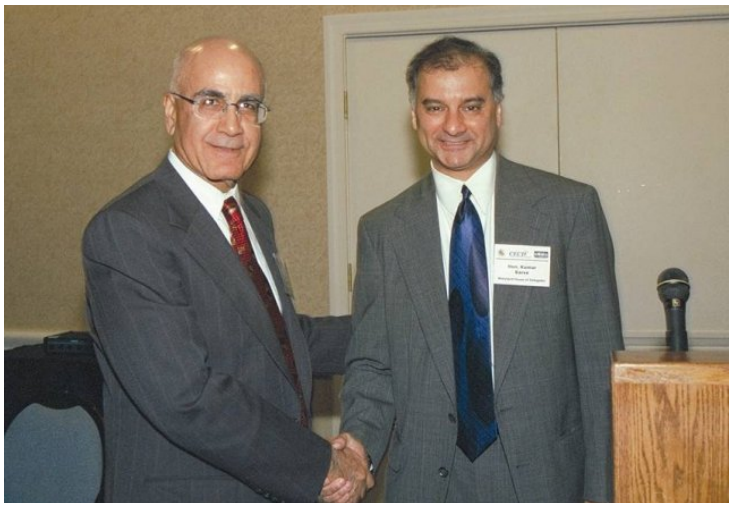
As part of the Center's outreach activities CECD established a graduate program in 2009, in addition to the traditional programs already offered by the Department. This new program was for the degree of Professional Master of Engineering in Energetic Concepts. A certificate program was also offered in Energetics beginning in 2012, consisting of four unique courses in the field. As of 2018, 31 Masters' degrees and 7 Graduate Certificates in Energetic Concepts were awarded through this program.

While several engineers and scientists worked together upon specific products, five appointments in CECD were targeted to achieve very specific goals. They include the following:

- Robert Kaczmarek was appointed as Senior Visiting Research Scholar in Mechanical Engineering for one year.
- Robert Kavetsky was appointed as senior scientist in Mechanical Engineering for one year.
- William Cocimano was appointed as a Senior Research Scientist with CECD, and worked with NAVSEA in Washington DC.
- Dr. Jerry W. Forbes was appointed as an Adhoc Visiting Professor of Mechanical Engineering at the University of Maryland.
- Dr. Thomas M. Klapötke, Professor of Mechanical Engineering from the Ludwig Maximillian University (LMU) in Munich, Germany, was appointed as Visiting Professor of Mechanical Engineering and Chemistry.

CECD hosted several symposia and lectures as part of our continuing activities, both here and abroad. These included topics such as Energetics, Traumatic Brain Injury, Critical Materials, Automation, Computation Enabled Materials Discovery, Data Driven Design, and Engineering for Social Change. The largest symposium we organized and supported was the International Detonation Symposium over a period of 16 years. These symposia, with an average of 350 attendees, were held in San Diego in California, Richmond in Virginia, Coeur d'Alene in Idaho and San Francisco in California.

The first CECD Research Review Day was held on May 21, 2003. It was attended by the Honorable Kumar P. Barve, the Majority Leader in the Maryland House of Delegates, Steve Mitchell, Technical Director at Naval Surface Warfare Center Indian Head (NSWC-IH) and almost fifty scientists and engineers from UM and the Navy.



Davinder K. Anand (CECD) and Delegate Kumar Barve

In recognition of the fact that the Southern Maryland region had a long history of contribution to the field of energetics development, CECD proposed the establishment of South Maryland Initiative for Energetics Capability Development in 2004. The base at Indian Head had been a leader in Navy ordnance development and testing for over 100 years. The need for this initiative arose from two pressing requirements, both critically linked to U.S. national security. The first was the imperative to regenerate the energetics professional workforce. The second was the essential need to develop ever more sophisticated systems in a timeframe that will ensure our national security.

MOU Signing Ceremony: US Congressman Steny Hoyer; US Senator Paul Sarbanes; N-STAR Director Bob Kavetsky; MD Senator Mac Middleton; Charles County Commissioners President Wayne Cooper. Seated: Capt. Joseph Giaquinto, Commander, IHDIV/NSWC; Prof. Dave Anand, Director, CECD; Ms. Ann Smith, Dean of Career & Technical Education, College of So. Maryland. April 25, 2005.

Ribbon cutting ceremony for the Energetics Technology Center in La Plata, MD. Attendees included Maryland Senator Barbara Mikulski.

The Southern Maryland Initiative for Energetics Capability Development would meet emerging national needs by expanding and enhancing the mission of the Center for Energetic Concepts Development (CECD) at the University of Maryland and the establishment of the Energetics Technology Center (ETC). The initiative was funded by ONR, and ETC was founded with headquarters in La Plata, MD. ETC was developed to conduct applied research and technology development largely in Charles County Maryland facilities in partnership with the College of Southern Maryland and selected industry/technology institutions nationwide. The Center was formally established with a

public ribbon cutting in La Plata, Maryland by Senator Barbara Mikulski on October 12, 2006.

On December 14, 2008, CECD celebrated its achievements in advancing the field of energetics and training the next generation of energetics experts. CECD hosted the celebration of our tenth year with University of Maryland Chancellor William Kirwin and Senator Mac Middleton as the keynote speakers.

CECD celebrates its 10th anniversary, with guests from campus, government, industry and beyond.

By 2014 CECD had expended almost $30M supporting over 250 projects funded by NSWC, ONR, ONI, NSF, ARL, AFOSR, HUD and the State of Maryland. Faculty from eleven University Departments and Schools were supported by CECD (see Table 1, which includes all the faculty supported as of this writing).

From left: Dylan Hazelwood (CECD), Maryland Representative Steny Hoyer, Davinder K. Anand (CECD), Delegate John Bohanan.

CECD did not keep an exact count of the graduate students we supported. However, a good estimate, based upon the monies given to the faculty, indicates that we have supported over 100 students for Masters and PhD degrees. The students, however, were under direct control of the faculty members whom we funded and the accounting would have been their individual responsibility. In addition, we awarded 31 Masters' degrees and 7 Graduate Certificates in Energetic Concepts.

The Post-2015 Period

With seventeen years of successful activities behind us, CECD entered a new era. While Dr. Anand continued as Director of CECD, Professor Peter Chung became the lead on all of our activities in energetics. Dylan Hazelwood formally became the Assistant Director and CECD now became the **Center for Engineering Concepts Development**. Rear Admiral (Ret.) Millard Firebaugh was appointed Minta Martin Professor of Practice and Dr. James Short became senior analyst. We received additional support from the Federal Highway Administration (FHWA) to support the activities of Dr. Short. As part of his duties he also became the editor of the Journal of Energetics. While we continued our work in energetics, we established a group in Engineering for Social Change (ESC). The relationship with NSWC and ARL continued, as did the support from the State of Maryland.

The Energetics research under the guidance of Professor Peter Chung consisted of signing a CRADA with ARL, continuing our research in energetics, which included the topics of computation enabled materials discovery, acoustic mixing, machine learning, and

participating in the Gordon conference. This work is being supported by NSWC, ONR, ARL, NSF, ETC and the State of Maryland.

The Engineering for Social Change (ESC) Program was developed in conjunction with the School of Public Policy. ESC is defined as the examination and mitigation of the unintended consequences of engineering on society. The program is comprised of the following components, namely; An innovative undergraduate course addressing the mitigation of the unintended consequences of engineering; Graduate research fellows; Undergraduate interdisciplinary teams; Collaboration with a community college within the State; An intern program with the Do Good Institute, and finally, the Engineering for Social Change book series. At the end of the year the program hosts an annual meeting and reception celebrating the successes of our students.

Students in the CECD Engineering for Social Change Course, Dean Pines, Faculty and Staff of Mechanical Engineering celebrate the Neilom Foundation grant to V-Linc, a local nonprofit working in assistive technology.

The successful Engineering for Social Change course was developed in conjunction with the School of Public Policy. As of 2018, 191 students from across the Engineering college had taken the course, and $50,000 had been awarded to local non-profit organizations on behalf of the Neilom Foundation, CECD's non-profit partner in ESC. This unique course sought to inculcate in our students an appreciation of the social change engineering creates and how both for-profit and non-profit organizations can act as catalysts.

The ESC Fellows initiative was designed to support the work of a graduate student in the Department with a grant of $25,000. The projects selected by a committee were chosen

as those that showed the most promise in creating positive social change. CECD supported the following projects:

- *Automated Palpation For Breast Lumps Using a Piezoresistive "Smart Bra"*, **Advisors:** Hugh Bruck, Elizabeth Smela, Miao Yu.
- *Probing Water-Holey-Graphene Interactions for Removing Lead from Water and Oil-Water Separation*, **Advisor:** Siddhartha Das.
- *Multi-Material Polyjet Printing for Fully 3D Printed Soft Robotic Prosthetics*, **Advisor:** Ryan Sochol.
- *Acoustic Waves for Non-Contact Removal of Chemical Hazards***, Advisor:** Peter Chung.
- *A Comparison of Water Quality and Energy Efficiency in two neighboring Maryland Counties*, **Advisor:** Jelena Srebric.
- *Explosive Wellbore Fracturing*, **Advisor:** William Fourney.

Continuing a long-standing relationship with the College of Southern Maryland (CSM), CECD reached out in 2015 to establish an offshoot of the ESC course held at the University of Maryland. This course emphasized the mitigation of unintended consequences through social entrepreneurship. The engagement of CSM students in developing team projects with local nonprofit organizations was highly successful. Student teams competed, and a panel of judges selected the most effective nonprofits and projects in the Southern Maryland community. After moving to CSM's newly formed Entrepreneur and Innovation Institute, this experiment expanded to a second campus in Spring 2018. After three impressive cycles, reaching dozens of local nonprofits, many CSM students and a variety of community members, the successful program then transitioned to being fully run by CSM as a permanent part of the curriculum.

CECD Outreach efforts culminate in the Entrepreneurship in Southern Maryland Challenge at the College of Southern Maryland. Pictured in the front row from left, Dylan Hazelwood (CECD), Bill Hitte (SBDC), Eileen Abel (CSM), Davinder Anand (CECD), Maryland Senator Thomas 'Mac' Middleton, CSM President Bradley Gottfried.

A book, entitled "Engineering for Social Change: Engineering is Not Just Engineering" was authored in 2016 by members of both CECD and CALCE to encapsulate the ideas underpinning the ESC program. This book was provided for free to students undertaking the course. CECD has a long history of publishing books in niche areas of interest, having published eight previous titles.

Table 1. CECD-supported Faculty

Department	Faculty
Mechanical Engineering	Ronald Armstrong, Shapour Azarm, Balakumar Balachandran, Amr Baz, David Bigio, Robert Bonenberger, Hugh Bruck, Steven Buckley, Jaime Cardenas-Garcia, Steven Chen, Nikhil Chopra, Peter Chung, William Cocimano, Siddhartha Das, Abhijit Dasgupta, Jaydev Desai, Donald DeVoe, Millard Firebaugh, Jerry Forbes, William Fourney, Mark Fuge, Satyandra Gupta, David Han, Henry Haslach, Jeffrey Hermann, Gregory Jackson, Mukes Kapilishrami, Robert Kavetsky, Kenneth Kiger, Thomas Klapotke, Maija Kukla, Edward Magrab, Michael Pecht, Peter Sandborn, Alba Ramaswamy, Janice Reutt-Robey, Maria Sanchez, Linda Schmidt, James Short, Elizabeth Smela, Ryan Sochol, Jelena Srebric, Miao Yu, Michael Zachariah.
Aerospace Engineering	Mark Lewis, Derek Paley, Kenneth Yu
Fire Protection Engineering	Jim Milke
School of Public Policy	Robert Grimm, Jennifer Littlefield
Chemical and Biomolecular Engineering	Bryan Eichhorn, Nam Sum Wang
Materials Engineering	Lourdes Salamanca-Riba
Electrical Engineering	Thomas Antonsen, Arthur Popper
Computer Science	Ashok Agrawala
College of Education	Matthew Miller
Department of Sociology	Jerald Hage
University of Maryland School of Medicine	Gary Fiskum and Rao Gullapalli