Summer 2016

WAVES

Carderock's success stories partnering with industry

Page 14

Contents

Technology

Partnering

Innovation

Investing

Cover

Close up of a SeaGlide in the miniature model basin during the Naval Surface Warfare Center, Carderock Division's SeaGlide summer workshop in West Bethesda, Md., July 22, 2016. In order to create the sea glider kits, Carderock Division partnered with Naval Undersea Warfare Center, along with the Association for Unmanned Vehicle Systems International Foundation to create Carderock's first three-party CRADA. (U.S. Navy photo by Devin Pisner/Released)

In this issue

Many of you are playing active roles in inspiring the next generation of naval engineers. As summer comes to a close, I applaud the many science, technology, engineering and math (STEM) and outreach programs that were conducted over the past several months. Not only is a robust STEM outreach program important to Carderock, it is also important to the nation. Science and technology innovation is what made this country great.

The cover photo of this issue of WAVES features a very innovative sea glider built during Carderock Division's SeaGlide Summer Workshop. The young imagineer who built the sea glider is part of Carderock's very robust STEM Program. Obviously, creativity is encouraged.

When I look at this cover, it reminds me of Tinkerbell. You may not realize it, but Disney recently gave this famous fairy a backstory. Her name is Tinkerbell because she's a tinker fairy. Each group of fairies has their area of expertise, and the tinkers are those fairies who solve the group's problems through mechanical engineering or, as the fairies like to call it, "tinkering." This is just one interesting example of how our culture is trying to reach the next generation of STEM leaders.

I know how generous our workforce is in giving of their time to support STEM because I sign stacks of thank-you letters to our volunteers every month. It really makes me proud to see the excitement on students' faces as they participate in our events, and I appreciate everyone doing their part to inspire future scientist and engineers.

In this issue, read about Carderock's support for full-ship shock trials. Each test requires extreme rigor to ensure instrumentation, explosive operations and environmental monitoring are all successful. The Carderock team is second to none in their contributions to the successful completion of the tests. Full-ship shock trials are only conducted on one ship in each ship class. The last full-ship shock trials were conducted on USS Mesa Verde (LPD 19) in 2008, which is an important reason for us to keep the knowledge and technical capabilities healthy.

You will see a number of stories in this issue related to power and energy and making ships more fuel efficient. As you read through our technical magazine, the one theme that runs through all of these stories is innovation! You can see why Carderock has a well-deserved reputation for excellence and innovation, so keep up the great work!

Dr. Tim Arcano
NSWCCD Technical Director

Team

Dr. Tim Arcano
Dustin Q. Diaz
Katie Ellis-Warfield
Megan Garcia
Rebecca Grapsy
Roxie Merritt
Kelley Stirling
Kevin Sykes
Margaret Zavarelli

Carderock supports third shot of shock trials on LCS 6

By Roxie Merritt, NSWCCD Public Affairs

Naval Surface Warfare Center, Carderock Division (NSWCCD) employees supported the third and final shot of the Full Ship Shock Trial (FSST) of USS Jackson (LCS 6), July 16. Carderock personnel had significant roles in the planning and execution of the test, which was a major milestone for the Littoral Combat Ship program.

Several months ago, Carderock personnel from three divisions from the Survivability, Structures, Materials and Environmental Department began the careful and difficult preparations to ensure the shock trial was safe and successful. The purpose of FSST is to validate the operational survivability of new-construction ships after exposure to underwater shock. Three tests were scheduled for the ship, and each test was conducted with a 10,000-pound explosive charge placed at various stand offs to the ship.

"Most of my team has been in Mayport, Florida, since April working in very hot and uncomfortable conditions," said Mike Brown, the department head. "Each test requires extreme rigor to ensure instrumentation, explosive operations and environmental monitoring are all successful. The preparation and execution done by the Carderock team was second to none and was a huge contributing factor in the tremendously successful tests." Carderock currently has 19 engineers and technicians on site to support the testing.

While the Navy will continue to assess the results for several months, the final test appears to validate the ability of the aluminum trimaran to meet operational objectives after exposure to underwater shock. This is a significant milestone for the LCS program and Independence-variant warships.

The Carderock team did extensive analysis with computerized prediction models and the live full-ship shock trials validate their results.

"Real-world trials are expensive," Brown said. "We use our analytical models to reduce the risk to the ship and to reduce testing."

The littoral combat ship USS Jackson (LCS 6) successfully completes the first of three scheduled full-ship shock trials (FSST) in the Atlantic Ocean, June 10.The shock trials are designed to demonstrate the ship's ability to withstand the effects of nearby underwater explosion and retain required capability. Naval Surface Warfare Center, Carderock Division personnel are supporting FSSTs on the two LCS variants. Trials are only conducted on one ship in each ship class. The last FSST was conducted on LPD 19 in 2008. Preparations are underway for USS Milwaukee (LCS 5) FSST in August. (U.S. Navy photo by Mass Communication Specialist 2nd Class Michael Bevan/Released)

Prior to any testing, the Navy ensures an exclusion zone is established around the test location. A notice to mariners is released before each shot stating that hazardous conditions to surface vessels may be present and for vessels not involved in the test to remain clear. Similarly, the Navy takes the safety and security of marine mammals seriously, and all testing is executed to avoid the various migration patterns of marine life. Additional lookouts are posted to detect any marine mammal activity, and test shots are not conducted if marine mammals are in proximity.

A story in the Florida Times-Union reported that headlines across Florida the week of the test declared an earthquake rocked the floor of the Atlantic Ocean just over 150 miles off the coast. Although it wasn't an earthquake, the blast, caused by the FSST 10,000-pound explosive, registered as a 3.7 on the Richter scale, which scientists use to measure earthquake magnitude. The Navy conducted another FSST on a Freedom-variant ship, USS Milwaukee (LCS 5), off the coast of Florida Sept. 4, which resulted in a similar earthquake-magnitude reading.

The last FSST was conducted eight years ago in 2008 for USS Mesa Verde (LPD 19) and was also conducted off the coast of Florida.

Carderock collaborates with Military Sealift Command on energy conservation efforts

By Rebecca Grapsy, NSWCCD Public Affairs

Military Sealift Command's Dry Cargo Ammunition class ship USNS Sacagawea (T-AKE 2) provides ammunition, food, repair parts, stores and small quantities of fuel for the U.S. Marine Corps. (U.S. Navy photo/Released)

During his time as chief of naval operations, Adm. Jonathan Greenert set the goal for 15 percent fuel reduction in the fleet by 2020, in line with Secretary of the Navy Ray Mabus' overall energy goals for the Navy.

In their energy conservation (ENCON) efforts, the Naval Surface Warfare Center, Carderock Division has collaborated with Military Sealift Command (MSC), whose ships represent about 13 percent of the Navy's annual operational energy usage, providing a significant opportunity to impact energy and fuel consumption.

Carderock engineer Sonjae Whang is the energy expert and program manager for this project, where he and his team oversee the development, procurement and installation of upgrades on new systems and the modification of shipboard operational processes to reduce energy and fuel consumption on Navy tankers, cargo ships and other auxiliaries.

Whang joined Carderock in 2009. He said that Carderock's Operational Logistics (OPLOG) ENCON group provides the research and development side of MSC's energy conservation efforts. In 2013, he also became the branch head of MSC's Energy Resource Branch, which gave him the opportunity to marry the development and shipboard implementation areas together.

The MSC ENCON program has five pillars: technology development and implementation; energy use tracking, reporting and benchmarking; operational improvements; policy guidance and development; and training and awards programs. Whang said that the technology development pillar gets the most attention.

The flagship initiative of the OPLOG team was what they call "iHVAC," intelligent Heating, Ventilation and Air Conditioning for MSC's dry cargo/ammunition Lewis and Clark-class (T-AKE) ship. The HVAC system of a ship is often the largest energy-using system on a ship behind propulsion, consuming about one third of a ship's total annual energy usage for this class. The iHVAC upgrades, which provide variable chiller and air-volume control and only touch a portion of air-handling systems on the T-AKE-class ship, save more than 15 percent of the total HVAC system's energy

usage, equivalent to approximately 240 additional underway hours per year. Reducing energy costs has real implications for the MSC fleet, resulting in increased capability, including longer range, more days on station, reduced maintenance and reduced frequency of refueling.

"We're engineers, and we like to work with new technologies that we can see and touch," said Whang in an interview about why the technology development and implementation pillar has the highest visibility within the ENCON program. However, "the biggest opportunity is really in the operational improvements pillar; the fiscal environment is shrinking our budgets so we have to get more energy bang for the buck."

Operational initiatives are much less costly to implement than hardware improvements. Behavioral changes require a level of buy in from mariners, but energy conservation hardware installations could be reduced in effectiveness if those operating the hardware aren't sold. For example, a crew could override or manually adjust automated engine-room ventilation fans or bypass smart controls, negating their effectiveness.

Whang's team also helped to develop a training curriculum for energy conservation, which has been integrated into MSC's existing technical training class. He said the program goes past the "why" of saving energy and dives in to the "how," providing mariners with the hands-on techniques they need to implement more efficient operating practices. The training is available at four levels, for senior engineers, junior engineers, senior deck officers and shore-side support staff.

Whang said that changing culture and behavior is not an easy task, but when he can utilize data to show a mariner exactly how much energy is being used, it can be easier to get him or her invested in using less. The awards component provides a means for those who are successfully implementing energy conservation changes to be recognized for their efforts.

Whang stressed the importance of taking feedback from mariners and incorporating it in to training and planning.

"If we all operated our work environment as energy consciously as we do our own homes, we could be increasing our energy savings just from finding smarter ways of doing the things we can control," he said, referring to a ship or office environment. "We need to push the envelope and continue promoting the value that new technologies and practices bring to our organizations."

Military Sealift Command's Dry Cargo Ammunition class ship, USNS Robert E. Peary (T-AKE 5), pulls into Naval Station Norfolk, April 28, 2016. (U.S. Navy Photo by Public Affairs Specialist Bill Mesta/Released)

Biofouling remediation equals higher speed, lower drag

Advancements in biofouling control R&D offer increased capability to Navy vessels

By Elizabeth Haslbeck, NSWCCD

Elizabeth Oakes, Navy Energy Coordination Office

Engineers and scientists at Naval Surface Warfare Center, Carderock Division (NSWCCD) have been studying commercial advancements that have the potential to improve hull and propeller coatings, thereby reducing the formation of biofouling and lengthening the intervals between cleanings.

Biofouling, also known as barnacles and slime, may not be the trendiest, high-tech topic of conversation in the world of operational energy. Most would rather discuss a new weapon system or innovative green technology that allows Sailors and Marines to increase operational tempo or achieve more efficient fuel consumption. What most people don't realize is that biofouling may actually represent the single largest factor undermining fuel efficiency in surface combatant and Military Sealift Command (MSC) vessels today.

The effects of biofouling are straightforward—biofouling accumulation increases the surface roughness of a hull and its associated frictional drag. Increased frictional resistance results in increased fuel consumption and decreased speed and range. To increase operational capability and efficiency, most would rather discuss swapping one design for another—maybe a new hull form, a new propeller design or a new technology that could result in more fuel-efficient operations, often ignoring the impact of something as uninteresting as biofouling. However, mitigating the effects of biofouling could result in significant increases in fuel efficiency and enhanced operational capability in terms of increased range and top speed.

Biofouling accumulation has been an issue for the Navy since the days of the sail, and the approach for mitigating biofouling—scraping the hull and propeller by hand or with grinding tools—has not been substantially improved in decades.

Improving hull and propeller coatings could reduce the formation of biofouling and lengthen the intervals between cleanings. A Carderock Division team has been studying advancements in commercial coatings and their applicability to Navy vessels. Carderock Division is also collaborating with Naval Sea Systems Command (NAVSEA) Energy, MSC Operational Logistics (OPLOG) Energy and other Navy research offices to better understand biofouling's direct effects on fuel efficiency and propulsion. Through better measuring of the costs of biofouling, remediation efforts can be monitored and marked as true improvements. In this way, biofouling research and development (R&D) plays a central role in operational energy advancements.

The challenges of biofouling

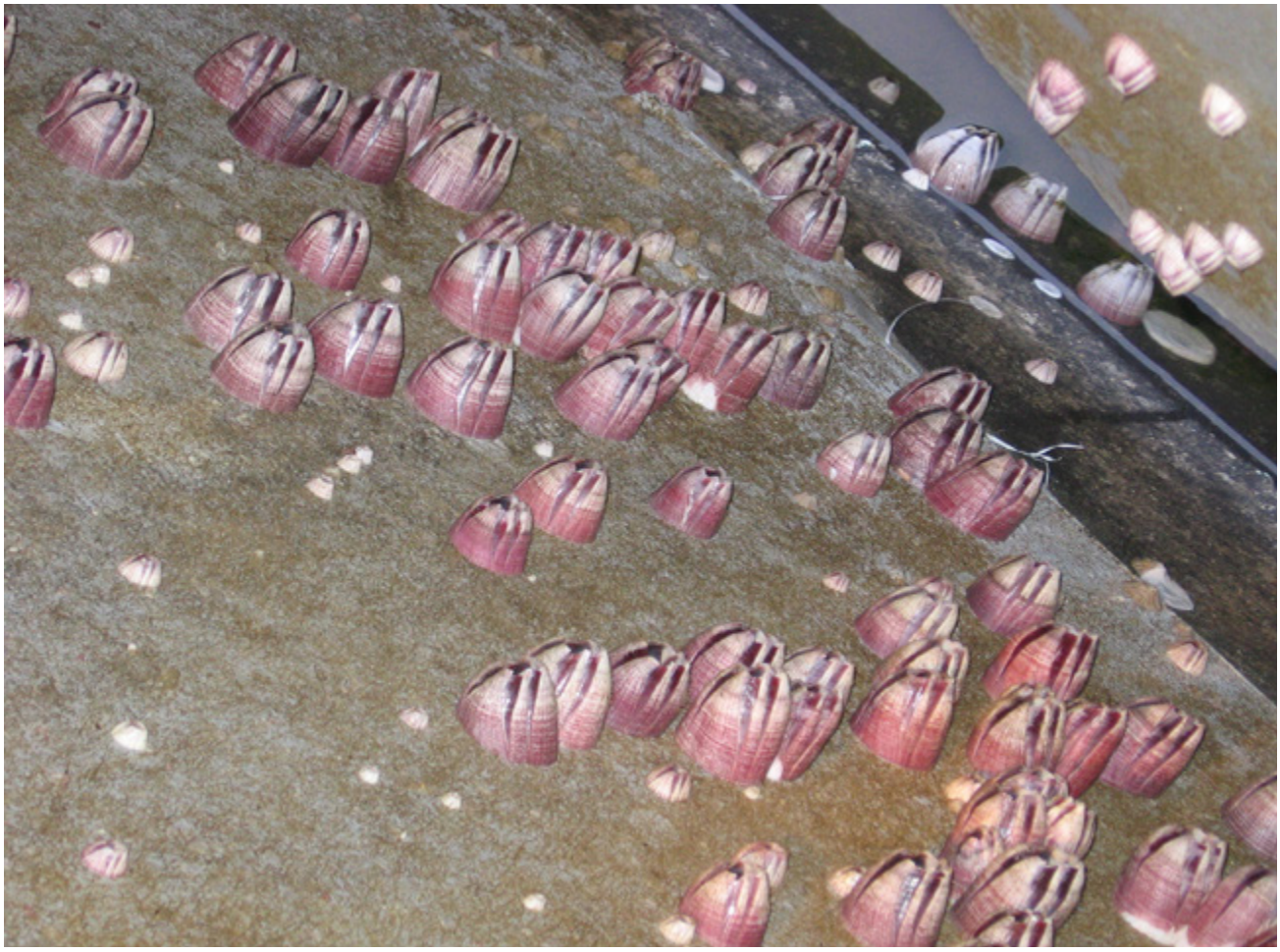
Biofouling describes the accumulation of microorganisms, plants and animals on wet surfaces. Types of biofouling are generally divided into two categories:

1. Soft biofouling: Biofilm slime, algae and seaweed.
2. Hard biofouling: Barnacles, tubeworms and mollusks.

The Navy uses a fouling rating (FR) score of zero to 100 combined with a percent area affected when describing the biofouling observed during underwater hull inspections. For example, FR-30 denotes heavy slime while a rating of FR-70 denotes medium-hard fouling.

The effects of biofouling accumulation and increased drag are well documented. A growing body of literature is expanding the Navy's understanding of the relationship between measured penalties associated with biofouling accumulation. The Carderock team estimates that approximately 14 percent of the propulsive fuel bill for the destroyer (DDG)-class fleet is wasted overcoming the effects of biofouling. This amounts to 410,000 barrels and $68 million per year. In 2011, Carderock personnel estimated that biofouling cost the Navy $180 million to $260 million per year. Modest

Biofouling may actually represent the single largest factor undermining fuel efficiency in surface combatant and Military Sealift Command vessels today.



Mature barnacles (Megabalanus tintinnabulum) on a Navy platform. (Courtesy photo provided)

improvements in the condition of the hull could yield substantial reductions in fuel consumption and cost. A 2010 article in Biofouling magazine concluded that the savings achieved from decreasing fouling from FR-30 to FR-20 in the DDG 51 class of ships would offset the costs of a biofouling control research and development program and all associated materials within a year. (Read the entire article at www.dtic.mil/dtic/tr/fulltext/u2/a575004.pdf.)

One of many technical hurdles associated with quantifying the impact of biofouling control improvement on fleet fuel efficiency remains the large variation in ship type and operational conditions across the fleet. It is also challenging to account for the type and coverage of fouling on hulls and propellers because measuring biofouling accumulation in and of itself is not a scheduling priority for the Navy. Measuring and quantifying biofouling impact is an important focus of ongoing projects.

The full costs associated with biofouling are not tied to fuel penalties alone. The increased frictional drag on a vessel also increases the shaft power required to attain a particular speed and can reduce vessel top speed. According to the Office of Naval Research, biofouling can reduce a vessel's speed by up to 10 percent.

One point remains clear: improved biofouling control will directly reduce drag and the associated increase in fuel consumed for propulsion. At the same time, mitigating biofouling returns capability to the vessel, an issue far broader than fuel consumption calculations alone.

A unique set of challenges in the Navy

The battle against biofouling is arguably more challenging for military vessels than for most commercial vessels for a number of reasons. The most important factor is probably tied to operational tempo, which is comprised of two main components – the frequency with which ships get underway and the speed-time profile of vessels when they are underway (the percent of time spent at each speed). The average Navy ship is underway less frequently than most commercial ships and steams at a lower and a wider array of speeds. Not only that, the operational profile of military vessels varies widely across ship classes, making them difficult to characterize. To make

Without a rigorous biofouling control R&D program, the Navy may continue to struggle to identify effective solutions and justify their transition with sound cost benefit analyses.

matters even more challenging, coating companies typically design biofouling control coating systems for the largest market sector (trade ships). Additionally, mission-essential factors can interfere with researchers' ability to demonstrate new solutions. These and an even wider array of interconnected variables present unique challenges to the Navy when working to bring advanced biofouling control solutions to the fleet.

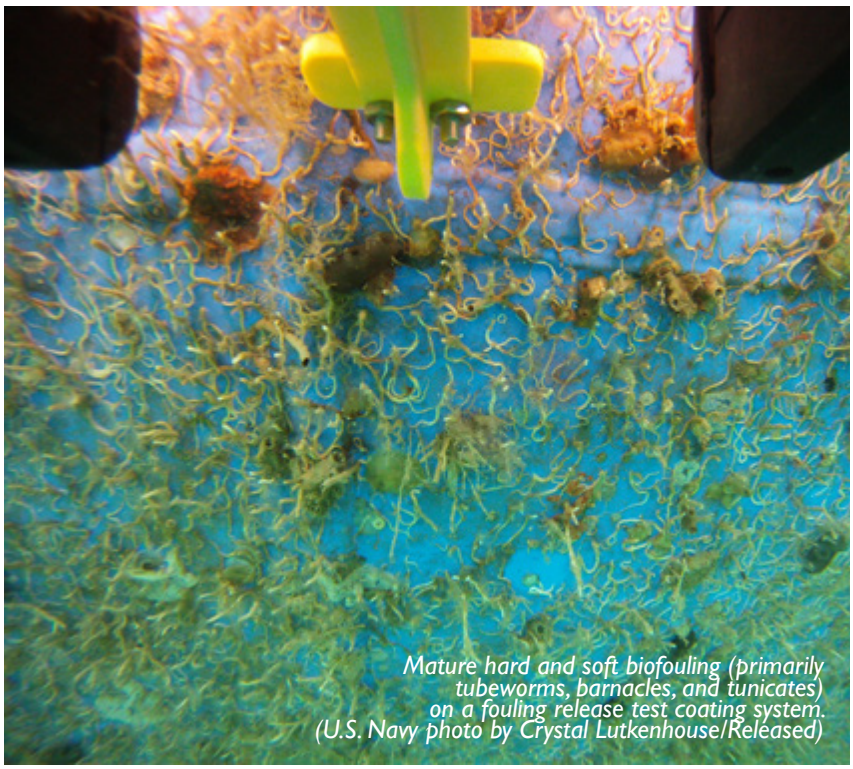
While the combination of advanced coatings and maintenance practices seems like a straightforward solution to the problem, the efficacy of these solutions is linked to a set of interdependent variables that must be taken into consideration in the overall analysis. Carderock has recently described this group of factors as the "4Ms"—materials, maintenance, monitoring and movement. For example, coatings fall under the materials "M." They should be applied after considering other elements of the vessel's activities:

- When and how often its hull and propeller are cleaned (maintenance)
- The quality and quantity of data associated with inspections and fuel efficiency measurements (monitoring)
- Its operating tempo and speed-time profile (movement).

Demonstrating and quantifying the benefits associated with advanced coatings are optimized only when all 4Ms are taken into consideration. (For more insights, see sidebar "More about the 4Ms.")

Recent demonstration projects involving new fouling release coatings highlighted weaknesses in the way the Navy currently screens, tests and quantifies the benefits of new coatings. It was determined that without a rigorous biofouling control research and development program, the Navy may continue to struggle to identify effective solutions and justify their transition with sound cost benefit analyses.

Working in collaboration with NAVSEA Energy, MSC OPLOG Energy, the Chief of Naval Operations Energy and Environmental Readiness Division (OPNAV N45) and others, Carderock has developed the Navy Biofouling Control R&D Program Plan. This R&D plan seeks to overcome the hurdles that currently get in the way of determining the best combination of solutions to the biofouling problem.



Mature hard and soft biofouling (primarily tubeworms, barnacles, and tunicates) on a fouling release test coating system. (U.S. Navy photo by Crystal Lutkenhouse/Released)

Not a one-size-fits-all solution

The Navy fleet has relied on copper-containing, oxide-based coating technology in combination with in-water cleaning for more than two decades. Because these formulas leach biocides into the surrounding waters, the Navy began to evaluate a new class of biocide-free materials called fouling release coatings in the 1990s. These coatings are based on the concept of reducing the ability of biofilm and barnacles to adhere to the hull (or propeller) through smooth surfaces and hydrodynamic forces. With a fouling release coating, the biofouling sloughs off when the ship moves.

Fouling release coatings represent at best 5 percent of the current commercial coatings market, but early reports from paint manufacturers and commercial vessels indicate a 10 percent improvement in fuel efficiency for tankers and 22 percent for bulk cargo vessels with their use.

Conceptually, these paint systems have great potential to provide a biofouling control solution for ship hulls and propellers, and they come with lower environmental impact than

legacy biocide-based coatings. In 2008, NAVSEA Energy funded a full-scale demonstration of a commercial fouling release coating on ship hulls and propellers. The International Intersleek® 970 coating system was applied to the propeller of USS Gunston Hall (LSD 44) and to the hulls of USS Cole (DDG 67) and USS Port Royal (CG 73).

After four years of monitoring it was determined that, as a hull coating system, this product did not perform as expected and the coating was not yet suitable for the hulls of many Navy vessels. This was largely due to the mismatch between the high volume of movement and speed required to slough off the biofouling and the current operating tempo and speeds of Navy vessels. Most ship classes do not regularly operate often or quickly enough to maximize the benefits of International Intersleek 970.

While the current generation of fouling release coatings may not have proven to be the panacea that they promised to be for the Navy, they did show promise in specific applications. For example, the fouling release coating performed better on LSD 41-class propellers than it did on hulls. No blade face cleanings were required through at least five years of performance. Early potential also exists on MSC propellers and other vessels with high operating tempos.

Early reports from paint manufacturers and commercial vessels indicate a 10 percent improvement in fuel efficiency for tankers and 22 percent for bulk cargo vessels with the use of fouling release coatings.

The 4Ms Affecting Biofouling

A complex combination of factors known as "the 4 Ms" affect the impact biofouling is likely to have on a ship's performance.

1. **Materials.** There are three main categories of coatings:
   - Antifouling: Contains biocides to inhibit bacterial growth
   - Fouling release: Prohibits biological material from affixing tightly and may be sloughed off when ship is underway
   - Durable: Withstands frequent cleaning (traditional hard coatings)
2. **Maintenance.** Tools and techniques used and maintenance frequency all affect coating and biofouling. Maintenance procedures must be compatible with coating material.
3. **Monitoring.** Hull and propeller fouling condition coupled with underway performance are critical for establishing a baseline, engineering a test plan and making any conclusions or recommendations regarding coatings.
4. **Movement.** Operating tempo, speed-time profile and operating area all affect ship performance and biofouling potential.

In the future, fouling release hull coatings that perform at least as well as, if not better than, Intersleek 970 may provide improved performance over legacy copper-containing coatings, especially if important formulation changes are made and/or if used on ships with much higher operational tempos. As a propeller coating, Intersleek 970 is being transitioned to the LSD 41-49 class vessels, and the Carderock biofouling team is evaluating the suitability of this and other more advanced coating technologies for other ship classes including a subset of MSC vessels.

The plan: near- and long-term

Near-term transition of improved biofouling mitigation strategies is the primary goal of the Navy Biofouling Control R&D Program Plan. This includes identification of mature, commercially available coatings and development of an effective maintenance regimen.

Because the current generation of fouling release coatings appears to be a poor match for the majority of Navy vessel hulls, the Carderock biofouling team plans to turn its attentions to emerging antifouling coatings in the near term.

Self-polishing copolymer (SPC) paint systems have been used globally for more than a decade now—and are currently being transitioned to the Royal Australian Navy—but have only recently become available for use in the U.S. These formulations contain biocides which aid in preventing biofouling formation. In

Propellers on USS Gunston Hall (LSD 44) after treatment with Intersleek 970 fouling release coating. (Photo provided by David Zuskin/Released)

fiscal year 2016, the team will perform an American Society for Testing and Materials test to determine the copper release rate of commercially available SPC formulations. Those products that release more copper than legacy copper ablative coatings used by the Navy will be disqualified. Those releasing the same or less copper will be included in planned panel and ship testing in early fiscal year 2017. The aim is to identify not only better-performing coatings, but also more environmentally friendly systems.

The Carderock biofouling team will leverage and build on lessons learned from their recent experience with fouling release coatings while applying the principles of the 4Ms.

In addition to testing emerging hull and propeller coatings, NSWCCD's R&D plan includes the following:

- Developing tools and models to calculate fuel savings associated with hull coating performance.
- Improving screening test methods.
- Characterizing ship operations.
- Tracking coating system service life, performance and maintenance history.

Among other collaborative efforts, the biofouling team plans to continue to engage with relevant members of the Navy community by attending several conferences such as the Fleet Maintenance and Modernization Symposium, the International Congress on Marine Corrosion and Fouling, and the Hull Performance and Insight Conference (HullPIC).

Summary

The challenges associated with defeating biofouling have existed since even before the birth of the Navy. NSWCCD and its partners and sponsors recognize the current opportunity to build on the momentum from recent projects to modernize the Navy's solution sets to biofouling remediation.

The solution to the biofouling problem in the military fleet is unlikely to be as simple as changing over to the newest hull coating technology, at least not without asking the right questions. NSWCCD's R&D plan attempts to identify the right set of interdependent variables to account for as they determine the suitability of biofouling control solutions for the Navy fleet. Reducing the fleet's baseline biofouling condition will reduce cost (fuel and maintenance) and enhance capability for Navy warfighters. When the NSWCCD-led efforts are successful, more ships can go to sea for the same fuel budget, and operational efficacy (top speed, range, time between re-fueling) will be enhanced. From the operational energy viewpoint, the Navy Biofouling Control Program will pay deep dividends in the long run.

Republished with permission from Currents—the Navy's energy and environmental magazine. Visit http://greenfleet.dodlive.mil/currents-magazine to browse and download past issues.

Carderock engineers showcase NISE/219 ideas to Pentagon leaders

John Grimes, a naval architect with the Center for Innovation in Ship Design, presents the Indicative Ship Design project to Capt. Mark Vandroff, now the commanding officer of Naval Surface Warfare Center, Carderock Division, during the Naval Innovative Science and Engineering/Section 219 Expo at the Pentagon April 21, 2016. (U.S. Navy photo by Monica McCoy/Released)

By Dustin Q. Diaz, NSWCCD Public Affairs

Engineers and scientists from Naval Surface Warfare Center, Carderock Division joined their colleagues from across the Naval Research and Development Establishment (NR&DE) to present a pair of projects at the Naval Innovative Science and Engineering (NISE)/Section 219 Expo at the Pentagon, April 21.

Goals of the event included highlighting the science and engineering work performed at Naval Sea System Command's warfare centers via the NISE/219 authority and showcasing the scientists, engineers, facilities and equipment that can be leveraged to solve the Navy's toughest challenges, according to Anne Adams, assistant to the Naval Surface Warfare Center (NSWC) chief technology officer.

Alex Askari, a mechanical engineer with Carderock Division's Advanced Power and Energy Branch, presented the Underwater Wireless Energy Transfer (UnWET) project, which won the 2015 Secretary of the Navy (SECNAV) Innovation Award in the Robotics/ Autonomous Systems Category for its potential to allow unmanned underwater vehicles to operate indefinitely away from underway platforms.

"It was a great opportunity for us engineers to show our work and meet with Navy leaders up close," Askari said. "The big thing for me was to be able to do that and talk to them about where we can make an impact."

John Grimes, a naval architect with the Center for Innovation in Ship Design, presented the Indicative Ship Design project, a mission-based, decision-making tool for surface-combatant, design-space exploration studies designed jointly by Carderock, NSWC Philadelphia Division and NSWC Dahlgren Division to analyze large complex data sets.

"The data set that we developed had over 8,000 different variants on a surface combatant and each one of them had 120 or so variables," Grimes said. "So if you think of that like a massive spreadsheet, it would have 120 columns and 8,000 lines. We developed a tool to try to help visualize that data in a way that makes sense, a way we can think about it and understand it."

Secretary of the Navy Ray Mabus; Undersecretary of Defense for Acquisition, Technology and Logistics Frank Kendall; Commandant of the Marine Corps Gen. Robert B. Neller; Vice Chief of Naval Operations Adm. Michelle Howard; and Assistant Secretary of the Navy for Research, Development and Acquisition Sean Stackley all attended the event, with 48 projects in total on display from the NR&DE.

"There was undeniable excellence demonstrated yesterday by the scientists and engineers that participated," Dr. John Burrow, deputy assistant secretary of the Navy for research, development, test and evaluation, wrote in an email thanking employees after the event. "The professionalism, technical knowledge and technical depth our scientists and engineers conveyed was exceptional and exactly what we wanted."

Carderock presents innovation at 51st Sea-Air-Space Expo

By Dustin Q. Diaz, NSWCCD Public Affairs

Employees from Naval Surface Warfare Center, Carderock Division (NSWCCD) presented technological advances in additive manufacturing (AM) and other areas at Sea-Air-Space in National Harbor, Maryland, May 16-18.

This is the 51st year the Navy League has collaborated with the sea services and defense and maritime industries to present the nation's largest maritime defense expo. Carderock employees were on hand to man booths, while Dr. Tim Arcano, Carderock Division's technical director, moderated an AM industry breakout session.

Arcano said the Department of the Navy (DON) has been experimenting with and exploiting AM for the past 20 years, and Carderock Division has embraced this technology with the opening of its Manufacturing, Knowledge and Education (MAKE) Lab, which provides training opportunities for all Carderock employees who want to learn about it and contribute their ideas. Arcano talked about the exciting possibilities for this technology to save time and money and enhance warfighting capabilities and how DON is actively working under the AM Implementation Plan to harness this technology.

"While there are multiple emerging efforts in AM, there are unique Navy and Marine Corps challenges that must be addressed to fully realize the benefits of AM for widespread implementation," Arcano said.

The panel consisted of leaders in DON, both military and civilian, who discussed these challenges, including the operational environment, setting uniform specifications and standards, and security of data; what DON is doing to address those challenges; and foundational advancements the services have made in AM.

"A lot of times when we put these technologies in the hands of Sailors and have them innovate, they can come up with solutions to these problems, and it's usually the best solution, vice whatever we can come up with in D.C. or a warfare center," said Capt. Frank Futcher, AM lead for Office of the Chief of Naval Operations. "But being able to link the scientists and engineers back up with the Sailors, it'll really be able to speed that process up.

Members of the additive manufacturing working group (right) from Naval Surface Warfare Center, Carderock Division at the Navy Energy and Innovation booth at Sea-Air-Space 2016 in National Harbor, Maryland, May 17, 2016. (U.S. Navy photo by Dustin Q. Diaz/Released)

"We can then get some of those solutions into a program, into a supply system, so the solution used on one ship is potentially applicable and utilized by the rest of the fleet. We need to be able to simplify, automate, understand environmental impacts, and how we're going to train and educate the workforce and use some of these new technologies that are coming out."

Also speaking at the panel were Dr. Justin Rettaliata, AM technical warrant holder for Naval Sea Systems Command; Liz McMichael, director of innovation for Naval Air Systems Command Aviation Readiness; Marine Capt. Chris Wood, AM co-lead for Headquarters Marine Corps; Navy Lt. Todd Coursey, fabrication laboratory project officer; and Dr. Jenn Wolk, program officer, Office of Naval Research, Naval Materials Science and Technology Division (formerly a Carderock employee).

Carderock's AM efforts were also represented at the Navy Energy and

Dr. Tim Arcano, Naval Surface Warfare Center, Carderock Division technical director, moderates an innovation industry breakout about additive manufacturing with other Department of the Navy leaders during Sea-Air-Space 2016 in National Harbor, Maryland, May 17, 2016. (U.S. Navy photo by Dustin Q. Diaz/ Released)

Innovation, DON AM Print-a-thon and Great Green Fleet booths. Members of the AM Tiger Team performed 3-D printing demonstrations at the Navy Energy and Innovation booth, while the Non-penetrating Optionally Manned Demonstrator (NOMAD) Print-a-thon team displayed the NOMAD unmanned underwater vehicle (UUV) technology demonstrator. NOMAD was one of five entries selected for display at Sea-Air-Space by the office of Dr. John Burrow, deputy assistant secretary of the Navy for research, development, test and evaluation. Harry Whittaker, team lead for Carderock's Sailor Performance Support Technology, said NOMAD is a wet submersible UUV that Carderock's employees are working with U.S. Special Operations Forces to create different designs, payloads and mission sets. He said using 3-D printing to create prototypes saves the government time and money in creating new versions of NOMAD.

"A prototype of the NOMAD hull can be created in one week for the cost of approximately $22,000, which includes material and the cost of 3-D printing," Whittaker said. "A vessel of similar size now costs $300,000 to $500,000 and takes three to five months to manufacture. Using AM technology allows us to build and field new prototypes quickly. We don't have to use a contract; this is all in house by the government. So that speeds up the process drastically."

Dominic Cusanelli, a naval architect with Carderock's Hullform and Propulsors Testing Branch, displayed a prototype bow bulb and stern flaps at the Great Green Fleet booth and talked to attendees about how these attachments, which are designed, created, tested and produced at Carderock, reduce drag and turbulence to increase propulsion efficiency on sailing Navy ships, reducing power and fuel use.

"Stern flaps have been on ships since 1988; there have been 191 installations to date on 14 classes, and they have saved the Navy $1.4 billion," Cusanelli said. "It's not small numbers. We're talking about huge amounts of fuel and money saved for the Navy at minimal cost."

Mike Lacny, an engineer also with Carderock's Hullform and Propulsors Testing Branch, displayed flap prototypes created in the MAKE Lab in the booth and said the Navy has recently adopted this technology for five classes of amphibious ships, which will receive their own flaps in the next few years.

Outside the expo's main space, Carderock employees also assisted with tours of the M80 Stiletto maritime demonstration craft, which is operated out of Carderock's Little Creek detachment.

Successful CRADAs at Carderock Division

By Katie Ellis-Warfield, NSWCCD Public Affairs

The Technology Transfer Office (TTO) at Naval Surface Warfare Center, Carderock Division maximizes their engineers' and scientists' ideas and fosters teamwork with invested stakeholders through the use of tools such as a Cooperative Research and Development Agreements (CRADA) and patent license agreements.

"Our main purpose is to use these tools to help us further the technologies and get the technology out into the hands of commercial companies such that they can turn around and produce the actual products the warfighter can then use," said Dr. Joe Teter, TTO director for Carderock Division. "We are here to solve problems."

A CRADA is a contractual agreement with one or more non-federal parties to perform cooperative and mutually beneficial research and development. Partners can include industry and private agencies, as well as both U.S. and foreign universities. Carderock Division can provide facilities, expertise, personnel and the use of patent licenses to such entities under a CRADA.

The use of CRADAs on Navy vessel M80 Stiletto is one of Carderock Division TTO's success stories. The concept was to expand the amount of testing being done for new technologies on the craft; however, the problem arose that there was no good way to legally bring outside companies onto the boat.

"This is where the TTO stepped in and came up with a new type of CRADA, called a limited-purpose CRADA, that would allow outside companies' representatives and their technology access to the boat in order to be able to go out and do an at-sea test," Teter said. "The new agreement protects their intellectual property and also protects the Navy's interests."

So far, the TTO has successfully brought 62 companies and their technology onto the craft. "We have taken it out and given it a real-world test drive," Teter said. "Whatever the company had that we thought was interesting to the small-boat community, we would allow on the boat to see how it would work."

Naval Surface Warfare Center, Carderock Division employees test different applications of an explosive resistant coating on helmets in West Bethesda, Md., Aug. 8, 2015. The coating is also being explored for use in football helmets and has a wide application in this arena. (U.S. Navy photo by Devin Pisner/Released)

The TTO has been able to implement testing on the boat such as radars, air autonomous vehicles and even something as simple as new kind of floor mat. "There is a lot of technology on the boat that the small boat community and other commands that use small boats are interested in," Teter said.

CRADAs can also be utilized in the education realm particularly for science, technology, engineering and math (STEM). "We are very involved with STEM education and needed a way of getting the work we were doing in developing new kinds of education kits out to students," Teter said.

Carderock engineers have developed STEM educational tools such as the

Stilletto off the coast of Virginia Beach, Va., April 21, 2015. A limited-purpose CRADA was created to allow outside companies' representatives and their technology to test on the Stilletto while at sea. (U.S. Navy photo by Devin Pisner/Released)

underwater SeaGlide. This autonomous underwater vehicle kit allows students to learn about buoyancy, electrical circuits and electronic sensors, as well as how to build and program a robotic controller.

Creating the SeaGlide kit required the production of parts and instructional materials, as well as kit assembly. Carderock Division decided to partner with Naval Undersea Warfare Center along with the Association for Unmanned Vehicle Systems International Foundation (AUVSI), a non-profit organization, providing students with hands-on STEM robotics activities. Out of this need for partnership came the first Carderock Division three-party CRADA.

"This allowed us to interact, and now we are getting the kits marketed for commercialization purposes by AUVSI at a reduced cost, allowing for a wider audience that can benefit from this work," Teter said. The Carderock Division TTO is currently in the process of getting this STEM product trademarked.

Most inventions and ideas require a long lead time, Teter said. It generally takes 15 years from concept to implementation and requires a sustained effort to get something out and actually have it used.

The plasma arc waster destruction system is a good example.

In problem solving how to limit waste on a ship, engineers at Carderock developed a plasma arc waster destruction system for incinerating garbage on a ship in a very effective manner.

The system grinds the garbage into very fine powder and injects it into a plasma gun. The plasma gun then incinerates it at such a high temperature that it breaks down into inert molecules, creating non-polluting gases to come out the stack and a significantly reduced waste ash content to be remediated upon the ship's return.

"The system worked very well, but the idea of having such a high-temperature plasma torch on a ship was against anything that the acquisition people have ever seen," Teter said.

Enter the TTO. "We came up with a solution in which we licensed both the patents and technology and entered into a CRADA with a company allowing them to build a commercial version," Teter said.

The commercial version was put aboard a cruise ship and through a CRADA; Carderock Division engineers had access to all the data collected on how the arc waste destructor preformed.

Teter said that after seven years of data collection, the plasma arc waster destruction system was found to be extremely safe and extremely efficient, convincing the Navy acquisition community that it was a viable technology. The first Navy insertion of this technology is on USS Gerald R. Ford (CVN 78), the Navy's newest class of aircraft carrier.

Through the use of CRADAs, Carderock Division has been able to bridge the gap with commercial entities allowing for resources and research to be shared in order to support the development and commercialization of new technology for both civilian and military use.

SEAP intern develops smartphone application for Sailors

By Dustin Q. Diaz, NSWCCD Public Affairs

A student with this year's group of Science and Engineering Apprenticeship Program (SEAP) interns at Naval Surface Warfare Center, Carderock Division created a smartphone application in direct response to interest from Sailors in the fleet.

David Papermaster, a junior at Churchill High School in Potomac, Maryland, came aboard the West Bethesda, Maryland, headquarters for an eight-week apprenticeship in June. Before he left Carderock, he had a working prototype app running that can assist Sailors with instant access to U.S. Navy environmental protection information.

"They came to me with a paper reference guide tool and they said, 'We need to make this easier. We want to make it easier to update; we want you to make this into an app.'" Papermaster said. "So I thought of the design and using past experience, made the functional application that we have so far."

According to his supervisor, Kiet Ung, team leader of the Hazardous Material and Pollution Prevention Afloat Research, Development, Test and Evaluation Group, he assigned this concept exploration to Papermaster because Sailors have told him and his colleagues they want to use this technology in their everyday work.

"The concept came from the bottom up," Ung said. "When we go out there and talk to Sailors on the deck plates, they're telling us, 'Hey, 98 percent of us have this technology already. We use apps to solve other problems in life; let's have a Navy app for things like this.' Technology is moving at an incredible pace, but with this, we're still sort of stuck in the Stone Age. What we use now is literally a paper reference guide. And we said, 'OK, this is an opportunity to develop this product.'"

Papermaster said he did not have experience in creating smartphone apps,

Pictured is a simulated graphic user interface of a smartphone application that can assist Sailors with instant access to U.S. Navy environmental protection information. David Papermaster, a junior at Churchill High School in Potomac, Md., created a working prototype of this application while a Science and Engineering Apprenticeship Program intern at Naval Surface Warfare Center, Carderock Division, in West Bethesda, Md. (U.S. Navy illustration by Michael White and Katie Ellis-Warfield/Released)

David Papermaster, a Science and Engineering Apprenticeship Program intern at Naval Surface Warfare Center, Carderock Division, programs a smartphone application for the Hazardous Material and Pollution Prevention Afloat Research, Development, Test and Evaluation Group in West Bethesda, Maryland, July 20, 2016. This application, the first Papermaster has ever developed, provides instant access to U.S. Navy environmental protection information. (U.S. Navy photo by Dustin Q. Diaz/Released)

but had enough of a baseline in writing computer code in school that he was able to get online and search for tutorials and training to fill in his knowledge gaps.

"This is a first-time thing for me," Papermaster said. "I'm using this as a starting point to learn about app development. I'm also working with Michael White (in Carderock's Visual Information Branch) to improve the app's layout and design to make it look as good as possible."

Papermaster said he has learned a lot about how the Navy manages waste during his time at Carderock, particularly during the hands-on work he requested to do in the Solid Waste Lab. This included creating plastic pucks in the Solid Waste Lab—the same kind made with plastic waste aboard Navy ships—and doing smell tests on odor barrier bags.

Peter Cheung, a mechanical engineer working with Ung, said these are the same bags used aboard submarines to store plastic waste because it cannot be discharged underway, and since a lot of that plastic has food contamination, it's crucial to ensure the bags used are strong, odor-sealed and heat-sealed to maintain quality of life for the Sailors aboard that submarine.

"He has opened the bags several times. These bags have food in them and they've been out in the sun. He hasn't had to deal with the smell yet. Maybe later on!" Cheung laughed.

Ung said when Carderock brings in new talent like Papermaster, passes on knowledge to them and embraces their ideas, it benefits both parties and embodies how the command has developed and uses new talent.

"This is our succession planning. What makes a place like this, with the reputation we've had and as long as we've had it, is the ability to bring in talents as early as the high school level and college," Ung said. "They bring us skill sets that we middle-of-the-pipeline folks don't have. If I engage with a contract to design and build this app, it'll probably be a huge cost. Here, we can incubate an idea and bring it to NAVSEA (the Naval Sea Systems Command) at a lower cost.

"It's a two-way street. We benefit and they benefit. We can also show them that working here is no different than going to school, except they pay to go to school. Here, people like David come in, acquire knowledge and solve problems, but unlike school, work pays them. So hopefully he'll leave this place knowing if he goes out and works hard in school, he might be able to contribute to the Navy as a career in the future."

Papermaster said he also spent time with the Center for Innovation in Ship Design during his summer internship at Carderock since his interest is in design and he has experience in computer sciences.

"I wanted to get a lot of experience in different fields to decide which one I want to get into in college and beyond, and that has definitely happened for me here," Papermaster said. "It's a good environment; I've had fun working here. I'd consider it in the future."

Carderock employee awarded for historic missile test

By Dustin Q. Diaz, NSWCCD Public Affairs

SeaRAM, a new system for guided-missile destroyers, is test fired in the Atlantic Ocean March 4, 2016, from the guided-missile destroyer USS Porter (DDG 78). Porter is forward deployed to Rota, Spain, and is preparing for deployment in the U.S. 6th Fleet area of operations in support of U.S. national security interests in Europe. (U.S. Navy photo/Released)

A Naval Surface Warfare Center, Carderock Division (NSWCCD) employee received a Program Executive Office for Integrated Warfare Systems (PEO IWS) Excellence Award, July 28.

Brian Lang received the award for his critical role in the first live-fire test firing of a Sea-Launched Rolling Airframe Missile (SeaRAM) weapon system from a guided-missile destroyer.

Lang, a SeaRAM Team member with Carderock's Underwater Explosions Research and Development Branch, was aboard guided-missile destroyer USS Porter (DDG 78) when testing began at sea near Rota, Spain, Feb. 25, which was also the first time Rota's test range was used.

"It's exciting to fire a new missile system for the first time," Lang said. "In this case, the concept moved from a white paper to actually shooting down a drone in 12 months, so that was pretty impressive. SeaRAM extends the range that destroyers over the Mediterranean [Sea] can intercept incoming threats – missiles, drones, that kind of thing. It increases defensive capability."

The SeaRAM close-in weapons system (CIWS) is a complete combat weapon system that automatically detects, evaluates, tracks, engages and performs kill assessment against anti-ship missiles and high-speed aircraft threats in an extended self-defense battle space envelope around the ship. It combines two fleet-proven weapon systems -- Block 1B Phalanx CIWS and the RAM Guided-Missile Weapon System. It also features an 11-round launcher assembly missile system on a single mount.

Lang said Naval Surface Warfare Center, Dahlgren Division, the lead warfare center for structural test firing, asked for Carderock's assistance in testing the missiles. Lang led the Carderock team of three other employees who assisted with testing the missiles – Craig VandeVusse, who works with Lang, and Matt Strawbridge and Shahram Kazemzadehmarand of the Dynamic Measurements and Testing Branch. Lang said they deserve equal recognition for successfully supporting the SeaRAM structural test firing.

"Every new weapon-launching system that goes on any ship has to have a structural test firing. You have to make sure the ship is not going to get damaged from firing its own weapons," Lang said. "We installed strain gauges and accelerometers in and around the SeaRAM, underneath it and on the structure that supports it. So we did the structural measurements and took the data to make an assessment on whether firing the missile would damage the ship or not. Our role was very small, but critical. We're part of the test and evaluation team that makes sure a new system is safe to deploy."

Lang said he thought the test went very smoothly and was well-coordinated, especially with so many different government agencies and contractors involved, and added he appreciated going to Rota and getting underway aboard Porter to do the work.

"It was planned well and executed well," Lang said. "It's always good to be reminded of why we're here working, because we don't interact with the operational side of the Navy much. It's also rewarding to see where the end product goes and how it is used, as well as seeing how the Sailors are living and talking to them."

Rear Adm. Tom Druggan, the major program manager for AEGIS Integrated Combat Systems in PEO IWS at the time, praised the SeaRAM Team for their contributions to a successful project.

"The successful March 2016 Combat System Ship Qualification Trial of the SeaRAM capability concluded a year's worth of ground-breaking effort for the engineering and acquisition professionals in PEO IWS," Druggan wrote in the team's award nomination. "The accomplishment of this unprecedented effort demonstrated programmatic and technical excellence as well as individual dedication to the mission that should serve as an example to all."

Carderock researchers enhance data-gathering capabilities

By Dustin Q. Diaz, NSWCCD Public Affairs

Researchers from Naval Surface Warfare Center, Carderock Division were recognized at an all-hands meeting July 21 for creating a self-contained submersible stereo particle image velocimetry.

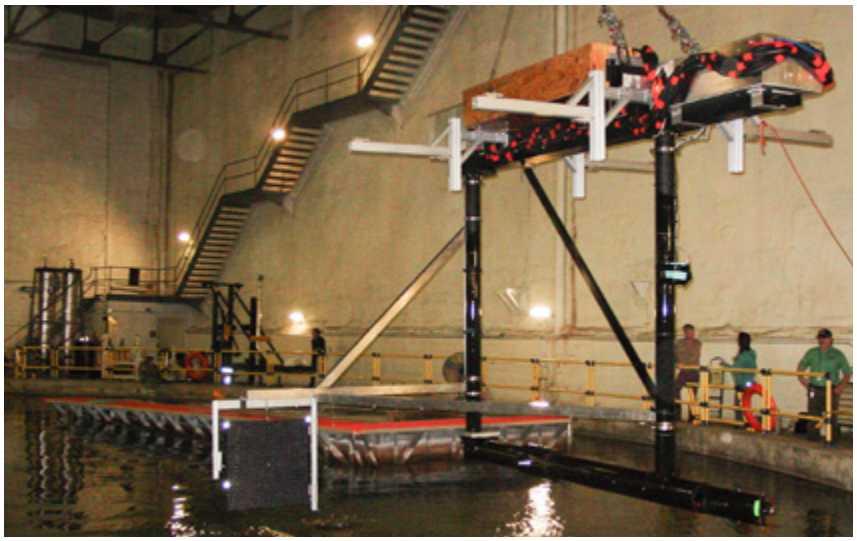
The scientists and engineers from Carderock's Naval Architecture and Engineering Department not only created, but also successfully tested the system in the David Taylor Model Basin in West Bethesda, Maryland, in the spring.

Dr. Emily Harrison, a naval scientist with the Hydrodynamics and Maneuvering Testing Branch, said the completion of this multi-year project produced the best particle image velocimetry results ever seen at Carderock and will save the government money in testing time moving forward.

"This test produced the largest data set of the highest quality data we've seen to date," Harrison said.

Particle image velocimetry is a technique to measure fluid velocity, done at Carderock by taking multiple images of water and comparing the distance and direction particles in that water move from one image to the next. Harrison said this is done using a laser camera-based craft at Carderock to validate computational fluid dynamics models used in ship design. Conventional particle image velocimetry is done in a two-dimensional grid, providing a velocity field and two components of velocity. Stereo particle image velocimetry offers multiple advantages, including a second camera that introduces a third dimension of data, and this system facilitates the newest iteration of stereo particle image velocimetry in use at Carderock.

"Stereo particle image velocimetry gives you two cameras that look at the same physical field, but it allows you to resolve the third component," Harrison said. "In our case, the two cameras are separated by a 30 degree-looking angle, but both are contained in a single pipe-shaped system we call the 'torpedo.' The advantage of using the torpedo to do PIV is that we are dragging it in one dimension, so we are not creating a giant wake by the measurement system itself. This minimizes the effect of the instrument on the flow field you're measuring."



Researchers from Naval Surface Warfare Center, Carderock Division created and successfully tested a self-contained submersible stereo particle image velocimetry system (pictured with calibration target attached) in the David Taylor Model Basin in West Bethesda, Md., spring 2016. The new system was designed, assembled and instrumented in house by about 25 employees in five divisions within the Naval Architecture and Engineering Department, led by the Submarine Maneuvering and Control Division. The data collected will ultimately assist the Navy in ship design. (U.S. Navy photo by Emily Harrison/Released)

The new system was designed, assembled and instrumented in house by about 25 employees in five divisions within the Naval Architecture and Engineering Department, led by the Submarine Maneuvering and Control Division. Harrison was the test lead for the system, which has a 2-feet by 2-feet measurement plane with more than 20,000 velocity points that can be traversed beneath the system's carriage.

"This system was built as an enclosed unit, so when you want to go use it, you can just take it, put it in the water, attach to the carriage and you're good to go," Harrison said. "You don't have to take it apart and reassemble it between uses like our previous system."

Harrison said the system takes velocity measurements at 8 feet under water to avoid surface effects and also brings a significant increase in camera and laser technology that improves the quality and quantity of data the system generates, which is important in larger facilities like those at Carderock.

"The amount of laser intensity you're imaging gets weaker over a larger field," Harrison said. "Originally, these were used for small water tanks, but as you expand, everything becomes harder. We're now using a more powerful laser, so this was a significant upgrade in laser quality and quantity in the towing basin. The same is true of the camera technology."

The use of this laser during the test, which ran from late February through late May in the J-Basin of the David Taylor Model Basin, was designed to withstand being in the water for so long, since cameras and lasers normally aren't designed to be submerged for so long, Harrison said.

"This one is instrumented with a full environmental monitoring system, so that we can keep an eye on it," Harrison said. "We can make sure the instrumentation is behaving as it should, that it's not in any sort of trouble with temperature and relative humidity, and we can keep it at its peak condition during testing. It paid off in the end; we had no issues.

"We were all very excited to see it tested and the quality of the data we got out of the system," Harrison added. "The system itself is a very unique tool that we now have."

Interns pilot NAVSEA Additive Manufacturing Challenge

By Dustin Q. Diaz, NSWCCD Public Affairs

College and high-school interns at Naval Surface Warfare Center, Carderock Division raced boats they printed and assembled themselves during the inaugural Naval Sea Systems Command (NAVSEA) Additive Manufacturing (AM) Challenge in West Bethesda, Maryland, July 28.

Intern groups were given one month to design and build a proof-of-concept surface vehicle. Each group was given a standard kit of parts and access to the Manufacturing, Knowledge and Education (MAKE) Lab's 3-D printers. Once the vehicles were built, participants were challenged to maneuver through an obstacle course in the David Taylor Model Basin, said Michael Britt-Crane, AM Tiger Team member.

"The basic idea is that we have a standardized set of components: motor, battery, electronic speed controller, the RC system and servos. Each group has that same set of components and just about everything else is 3-D printed," Britt-Crane said.

The NAVSEA AM challenge is testing out concepts the AM Tiger Team has for AM to support the Navy and Marine Corps in a forward-deployed environment.

"The idea in the far future is we'll have all the electronics on the shelf and have 3-D printers forward deployed. With reference designs on hand, a Sailor would have the capability to 3-D print an unmanned vehicle and deploy it within a very short time frame. Vehicles could even be customized for a specific mission." Britt-Crane said. "So these guys are kind of testing that concept out. One of our groups built theirs in just a week."

Students created boats named "Mongoose," "Porky" and "USS Boaty McBoatface" with a common set of components, but with original designs. The watercraft were printed using 3-D printers in Carderock's MAKE Lab. Sean Black, who created Mongoose with his teammates Matthew Dapp, Brooke Merryman and Jacob Blumberg, said

Student interns at Naval Surface Warfare Center, Carderock Division, pilot watertight proof-of-concept vehicles in the David Taylor Model Basin during the inaugural Naval Sea Systems Command Additive Manufacturing (AM) Challenge in West Bethesda, Md., July 28, 2016. The AM Challenge gave interns one month to design and build a proof-of-concept vehicle with a standard kit of parts and the command's 3-D printers, then maneuver them through an obstacle course. (U.S. Navy photo by Dustin Q. Diaz/Released)

Additive Manufacturing (AM) Tiger Team member Michael Britt-Crane (left) helps student interns at Naval Surface Warfare Center, Carderock Division, put the finishing touches on their watertight proof-of-concept vehicles in the David Taylor Model Basin during the inaugural Naval Sea Systems Command Additive Manufacturing (AM) Challenge in West Bethesda, Md., July 28, 2016. (U.S. Navy photo by Dustin Q. Diaz/Released)

combining their knowledge was essential to creating a functional vehicle.

"Brooke and I had additive manufacturing experience before this internship; our other teammates didn't, to my knowledge, but Brooke and I didn't have naval architecture experience, so we didn't know where to start or how to go about this," Black said. "All we know is we have to design a ship and 3-D print it. That part I can do no problem. We started by modeling our design after the first thing we thought of that would be easy and quick to model: a rowboat shape. Michael set us up with teammates who had more knowledge about naval architecture who gave us ideas on how to make the ship turn better, go faster and be more stable.

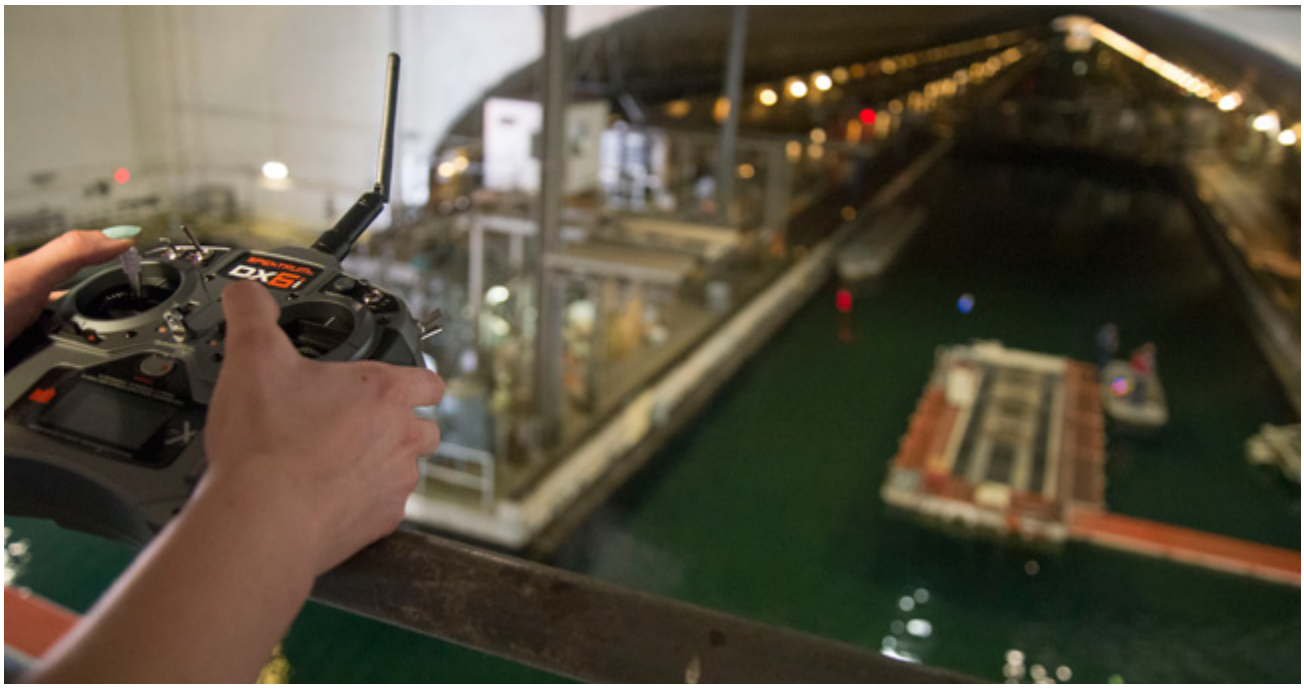
"We had many failures and we were really pushing the printers to their limits. Trial and error is how we learned. We slowly adjusted our design, printed half-scale models and put them in the water to see if they would float. We went through doing different variations of our print, printing it over and over again until we were happy with it. I feel pretty good about our product. There are some changes we could have made to give us more speed. But I think our shape was decent; for the time we had, it's a great design. It's not at the bottom of the basin. That's what we're proud of. We definitely learned a lot about naval architecture that we didn't know before."

Black said his team competed with the very last print they made of Mongoose, which ended up winning the time trials over USS Boaty McBoatface by less than two seconds. While Porky came in last, Britt-Crane said it's understandable and still impressive considering that entrant was created the fastest. In the head-to-head competition, all three craft improved their times and USS Boaty McBoatface took first place.

"With all three running, they were bumping fenders and there was a lot of contact, but they all survived and finished the course," Britt-Crane said.

This was Black's fourth summer at Carderock under the Naval Research Enterprise Internship Program and the Science and Engineering Apprentice Program. He said he has spent a lot of that time working with AM and in the MAKE Lab, where he used the 3-D printers for this challenge, and that he has found working on projects like the AM Challenge rewarding and typical of what he has been able to do at Carderock Division.

"I have spoken to people who have been interns at other places, and some of them are just given busy work to do and their work isn't very important," Black said. "Here at Carderock, I know my work is important and I can see it being implemented. And the AM Challenge was a lot of fun; I'm really glad I got to



Katarina Sherman, a student intern at Carderock Division, pilots USS Boaty McBoatface, a watertight proof-of-concept vehicle, to victory in the inaugural Naval Sea Systems Command Additive Manufacturing Challenge in West Bethesda, Md., July 28, 2016. Sherman and other Carderock interns had one month to design, print and race vehicles in the David Taylor Model Basin using a standard set of parts and 3-D printers for the challenge. (U.S. Navy photo by Dustin Q. Diaz/Released)

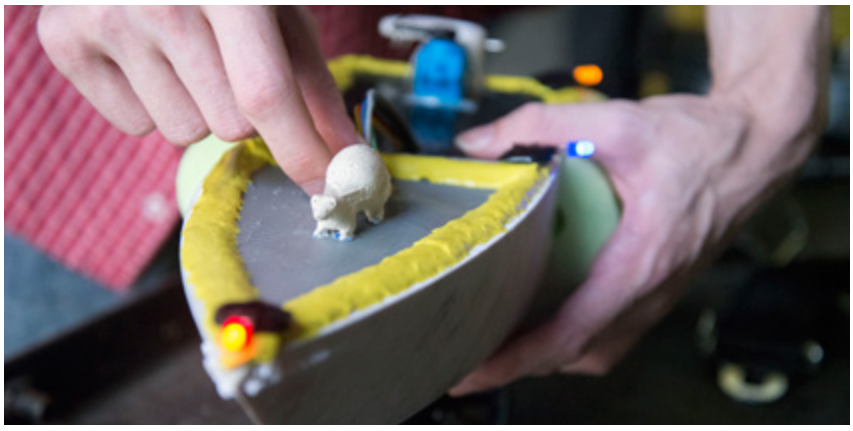
be a part of it. We learned a lot and it was definitely an enjoyable experience."

Britt-Crane said the AM Tiger Team got the idea for the challenge by leveraging their Cooperative Research and Development Agreement (CRADA) with Virginia Tech, which has done similar AM-centered challenges with air and land vehicles. This first iteration is intended primarily as a pilot/demonstration to learn about the design space and show the work the challenge can produce, but he expects to expand the competition portion in future years to include print time and assembly as judging criteria.

The AM challenge is sponsored by NAVSEA 05, Chief Technology Office (CTO).

"3-D printing has been playing a major role within the naval industry and needs to be considered within the career exploration process," said Danesha Gross, program manager for Cross Platform System Development within the CTO. "There were some students who had never heard of 3-D printing until this competition, which is why funding this task was so important. With as much as we have already learned in this area, there are still so many concepts to still be learned."

"I was elated to see that we are using 3-D printing to teach our future naval architects and engineers how to be design thinkers, creative thinkers and learn the principles of a good design," added Gross. "These are the types of learning environments that should be showcased more at NAVSEA. I look forward to working more with our STEM (science, technology, engineering and math) teams at the Warfare Centers and discovering different characteristics of 3-D printing."



A student intern at Naval Surface Warfare Center, Carderock Division adjusts the watertight proof-of-concept vehicle Mongoose in the David Taylor Model Basin during the inaugural Naval Sea Systems Command Additive Manufacturing Challenge in West Bethesda, Md., July 28, 2016. (U.S. Navy photo by Dustin Q. Diaz/Released)

SeaGlide workshop for educators

By Megan Garcia, NSWCCD Public Affairs

Michael Britt-Crane (right), one of the facilitators of the Naval Surface Warfare Center, Carderock Division's SeaGlide summer workshop, helps participants build their gliders July 21, 2016, in West Bethesda, Md. During the week-long workshop, participants learned how to build and operate a SeaGlide using various mechanical, engineering and electronic skills. (U.S. Navy photo by Ryan Hanyok/Released)

Sixteen people from around the U.S. attended Naval Surface Warfare Center, Carderock Division's (NSWCCD) SeaGlide summer workshop July 18-22 in West Bethesda, Maryland, geared toward educators, scientists and engineers.

A SeaGlide is a small-scale underwater glider – a non-tethered, autonomous robot that has no propeller and uses very little energy.

A SeaGlide helps collect data through sensors, which helps scientists better understand and model the ocean. Although composed of many elements, its most important components consist of a microcontroller, or microcomputer, that runs off of programmed coding sequences that runs the buoyancy engine; the buoyancy engine, which controls the depth and angle of the glider; and the body, which encases the engine, the microcontroller, additional electrical components, and has plastic, custom wings and a fin attached to it.

During the workshop, participants learned how to use coding to program their microcontrollers; build buoyancy engines while also learning how to balance the forces of buoyancy and gravity; put their glider bodies together using plastic water bottles, custom components made in Carderock's Manufacturing, Knowledge and Education (MAKE) Lab, and basic electronic skills.

Erica Moulten, who founded the Center for Open Exploration in St. Petersburg, Florida, said she followed the SeaGlide program at Carderock for three years and had tried her luck at building her own SeaGlide before coming to the workshop to perfect her skills.

"It's been great," Moulten said. "I really enjoyed all the building components. I haven't had as much experience with programming and coding, so it was a learning curve."

Len Fischer, a middle-school teacher from Coconut Creek, Florida, said he was motivated to attend the workshop because he hopes to start an engineering program at his school that will allow students to receive high-school credits, while also helping them to understand the application of science in how things work.

"I think this is awesome," Fischer said. "I do a lot of hands-on, but not the actual building of circuits, so to be able to do this is a one-up for me."

Participants of the workshop also visited various labs and facilities on the base, but none were as important as the MAKE Lab, which Carderock engineer Michael Britt-Crane said is mostly directed to the SeaGlide mission.

Britt-Crane, one of the facilitators of the workshop, uses 3-D printing machines in the lab to conduct small-scale manufacturing of the custom parts for the SeaGlide. He said it helps cut cost and brings the production time down.

"We actually get a lot of good feedback from our participants about the lab," Britt-Crane said. "It's stuff they can use because they can actually go back to where they came from and get a 3-D printer and use it."

Toward the end of the workshop, the participants were able to test the structure and effectiveness of their gliders, putting into practice the things they learned and making adjustments as needed.

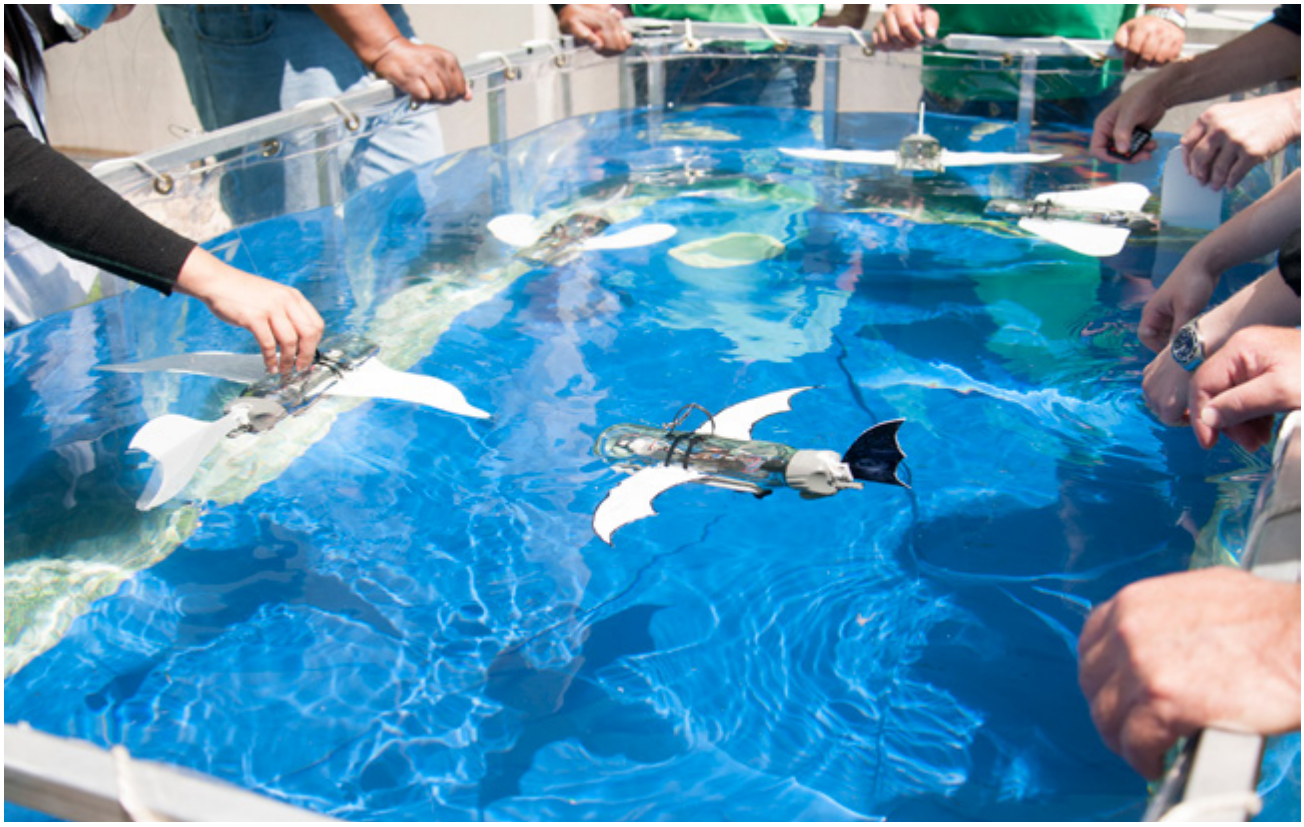
"I wanted to improve my fin design," said Fischer, who realized his design wasn't allowing his glider to stay straight. "It's definitely going to the right a little."

Nonetheless, Fischer said it was his first time doing something like that, and he was excited and proud of the opportunity to see his work put into action.

Moulten, who won a race among four gliders, said she used the concept of biomimicry to perfect the wings on her glider.

"It's basically using what you see in nature, using how sea animals move in the ocean," Moulten said. "I basically made wings to match that of how a manatee's fin helps it glide."

Tyson Tuchscherer, a contractor in hydromechanics, also serves as an education specialist with the SeaGlide program and was the originator of the



Sea gliders, built by participants in the Naval Surface Warfare Center, Carderock Division's SeaGlide summer workshop geared toward educators, scientists and engineers in West Bethesda, Md., are put to the test in an outdoor, mini pool July 20, 2016. (Navy photo by Megan Garcia/Released)

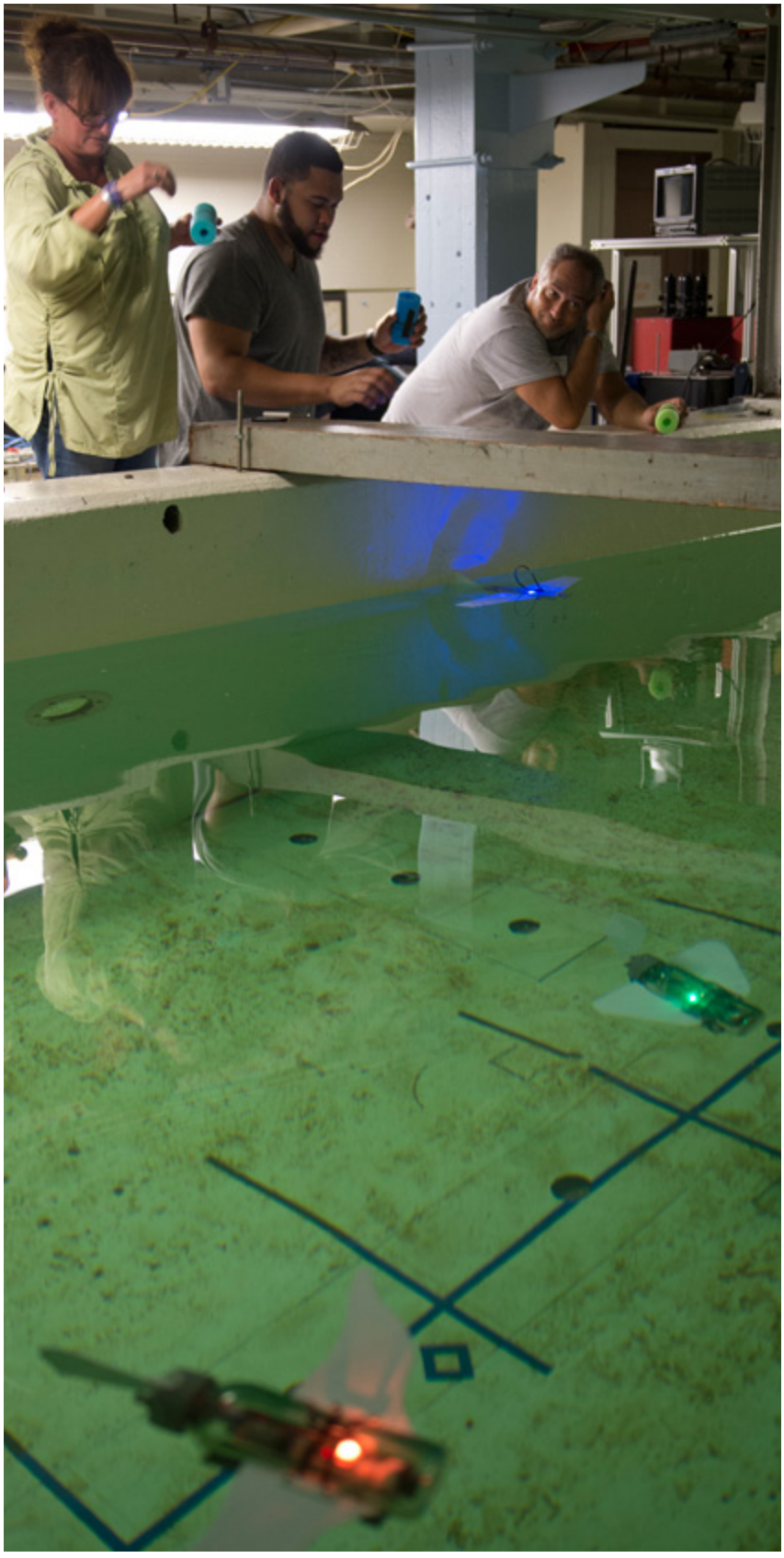
SeaGlide model used at Carderock. He came up with the idea after attending the 2010 National Science Teachers Association Conference in Philadelphia and hearing the story of and seeing the glider that successfully crossed the Atlantic Ocean.

Tuchscherer said overall what he would like is for everyone who attended the workshop to take what they learned and incorporate it into science, technology, engineering, and math (STEM) programs in their schools or communities.

"What we are hoping is that we can train the trainers, and they can help get others interested in STEM programs to maybe even work for the Navy or the Department of Defense," Tuchscherer said. "If we have more technically educated people, the world may be a better place."

Elizabeth McGlothen, a junior at the University of Alaska Fairbanks, is one person who is definitely going to take what she learned back to her school. McGlothen, who works in the Computer Science Department of her university, is hoping to teach her co-workers about the glider and go into middle schools with them to teach the students.

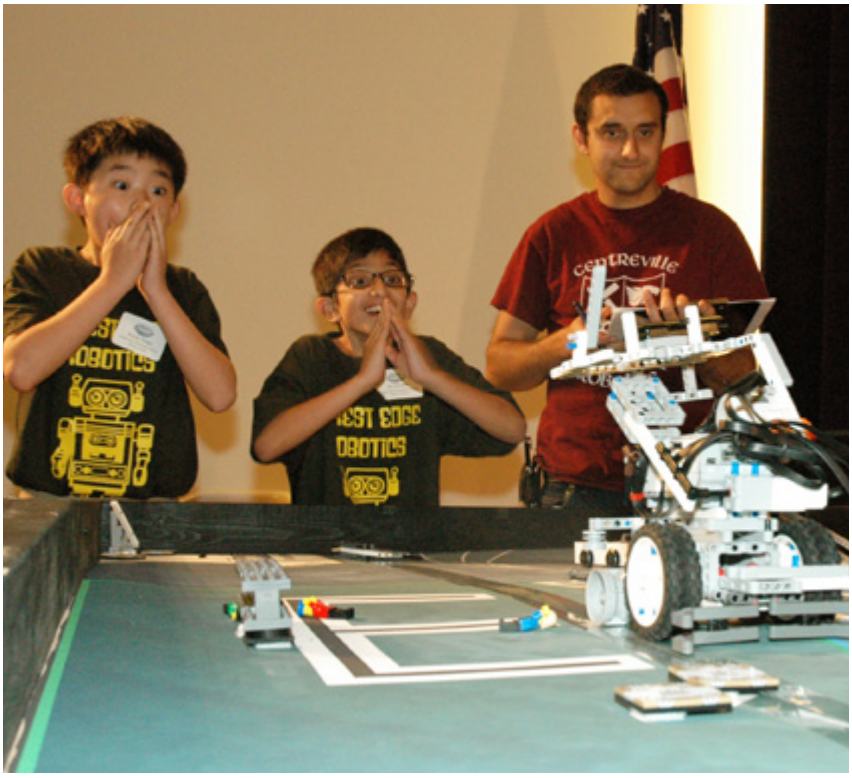
"The workshop helps us to learn how to do interactive training that students can learn from," McGlothen said. "We're learning how to make a connection."



Participants in Naval Surface Warfare Center, Carderock Division's SeaGlide summer workshop geared toward educators, scientists and engineers test their gliders at the end of the week-long workshop in the miniature model basin, July 22, 2016, in West Bethesda, Md. (U.S. Navy photo by Devin Pisner/ Released)

Annual robotics competition

By Dustin Q. Diaz,
NSWCCD Public Affairs



Kevin Shan (left) and Ali Sheikh, students from this year's first-place winning team, Forest Edge Robotics from Forest Edge Elementary in Reston, Va., test their robot for Naval Surface Warfare Center, Carderock Division employee Mina Samaan during the 2016 Carderock LEGO Robotics Competition in West Bethesda, Md., June 10, 2016. (U.S. Navy photo by Harry Friedman/Released)

Students from area elementary schools brought their creativity and ingenuity to Naval Surface Warfare Center, Carderock Division in West Bethesda, Maryland, for the 2016 Carderock LEGO Robotics Competition.

This year's competition was Operation Carderock, a Carderock-themed challenge that included robot missions aimed at educating participants about the command and its work, according to Nathan Hagan, competition volunteer coordinator and naval architect with the Structural Criteria and Risk Assessment Branch. Along with 2.5-minute matches at the "game board," students also competed in a teamwork activity, robot design judging and presented their research project focused at identifying and solving Navy problems.

"Normally, we've done games that have been designed by FIRST (For Inspiration and Recognition of Science and Technology) and LEGO," Hagan said. "LEGO designs the game and we just do it. For Operation Carderock, I designed all the missions. Then, with the help of volunteers, we built them. We are proud to finally have a Navy game of our own that reflects our culture here at Carderock."

Four schools participated in Operation Carderock, with two attending the June 10 competition. Wood Middle School in Bethesda, Maryland, and Pyle Middle School in Rockville, Maryland, competed previously at their own school facilities. At the Carderock competition, more than 50 students from Burning Tree Elementary School in Bethesda, Maryland, and Forest Edge Elementary School in Reston, Virginia, formed teams of 10, each with a robot they'd built and programmed with LEGO tools and software. Each team was scored on their ability to solve challenges with their robot, based around Carderock locations like the David Taylor Model Basin and the Maneuvering and Seakeeping (MASK) Basin; their ability to work as a team; ability to communicate their design decisions regarding their robot; and presentation for a team-produced research project.

"When the schools visit, their favorite part of coming here is seeing the facilities. They're here to see Carderock," Hagan said. "So we thought it through and we decided if we were going to design a game, let's make it be all about what we do."

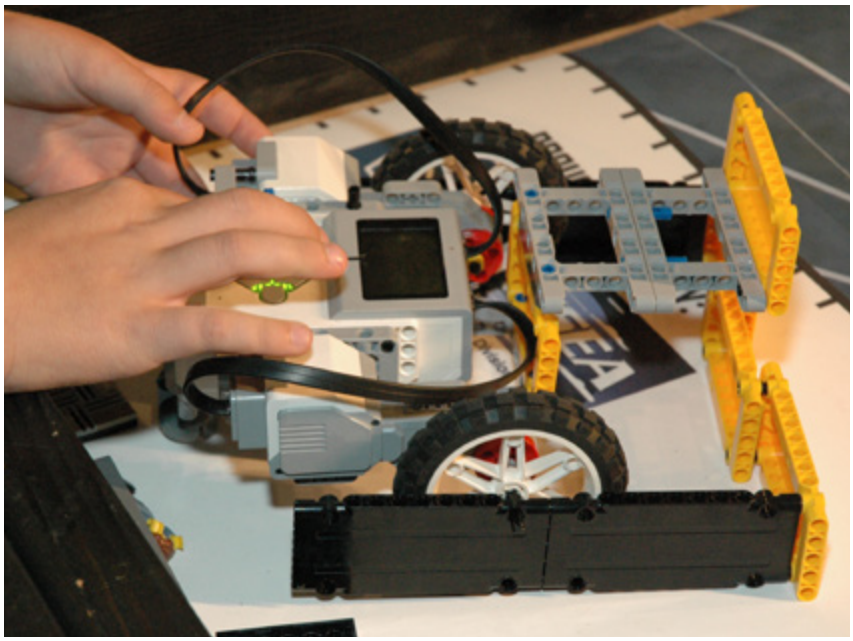
After the competition, the students toured Carderock's facilities and learned how the command and its scientists and engineers support the fleet with their work. Carderock employees served as chaperones to keep the students safe and answer their questions. Ryan, a fourth-grader competing with Techno Team, said seeing the 3-D printers in the Manufacturing, Knowledge and Education (MAKE) Lab was the highlight of the tour for him. "You can make anything you want. You can make it as colorful as you want, and you can make as much as you want if you have the material," he said.

This is the third time Carderock has hosted a LEGO Robotics Competition as part of its science, technology, engineering and math (STEM) outreach effort. Hagan said when he was a student like today's competitors and wanted to design ships, he didn't know how to go about pursuing it, so events like this are a useful resource for today's students.

Carderock 2016 LEGO robotic competition first-place winners, Forest Edge Robotics from Forest Edge Elementary in Reston, Va., pose with Naval Surface Warfare Center, Carderock Division Commanding Officer Capt. Rich Blank after the competition in West Bethesda, Md., June 10, 2016. (U.S. Navy photo by Harry Friedman/Released)

"The goal today is to get them oriented to Navy problems, Navy technical work and what we do here," Hagan said. "The whole point of these STEM programs is outreach for the Navy, so we decided to direct it toward things that are our technical work, engineering problems that we have, so that the kids in elementary school can understand the real work a Navy engineer does. As outreach, this is a good education opportunity. At the end of this, 100 more kids will understand what a naval architect is and what naval engineers do."

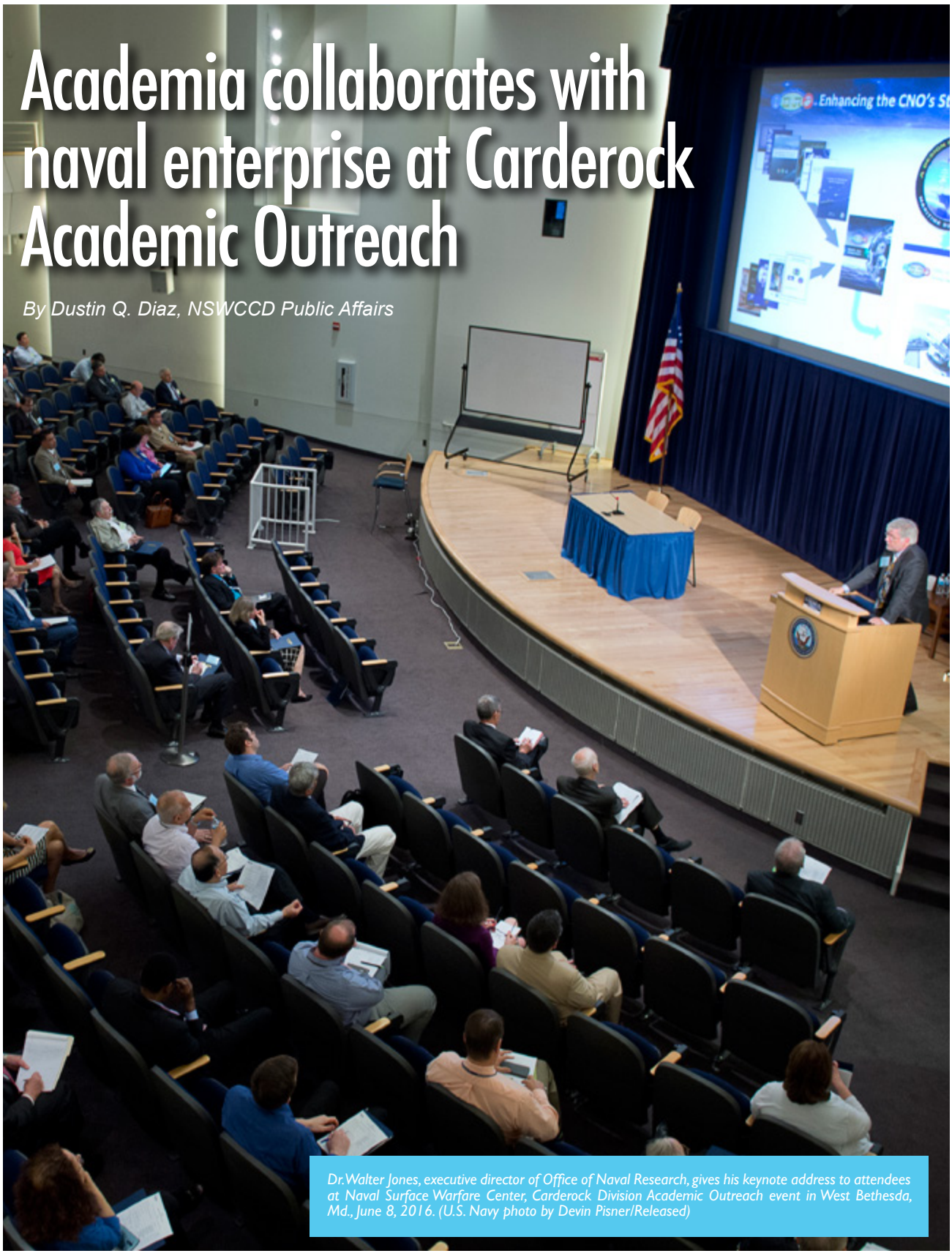
The Mindstormers of Forest Edge finished in third place, while the Road Ragers of Burning Tree came in second and the Techno Sharks of Forest Edge took first place in the 2016 Carderock LEGO Robotics Competition.



A robot is prepped for Operation Carderock by students at the 2016 Carderock LEGO Robotics Competition at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 10, 2016. (U.S. Navy photo by Harry Friedman/Released)

Academia collaborates with naval enterprise at Carderock Academic Outreach

By Dustin Q. Diaz, NSWCCD Public Affairs



Dr. Walter Jones, executive director of Office of Naval Research, gives his keynote address to attendees at Naval Surface Warfare Center, Carderock Division Academic Outreach event in West Bethesda, Md., June 8, 2016. (U.S. Navy photo by Devin Pisner/Released)

Investing
in our future

Academic representatives from 21 universities met with Naval Surface Warfare Center, Carderock Division and Office of Naval Research (ONR) employees in West Bethesda, Maryland, for the Carderock Academic Outreach event, June 8.

The intent of the event was to enhance collaboration among these representatives – including professors, college officials, interns and students – and members of the Naval Research and Development Establishment (NR&DE), according to Dr. John Barkyoumb, Carderock's director of strategic relations.

"We are discussing both the mechanisms by which we collaborate and finding where the barriers exist and what we can do to overcome them," Barkyoumb said. "The goal would be closer collaboration that speeds the transition of our technology and technology from the universities to the fleet and warfighter."

The event began with Carderock Division Technical Director Dr. Tim Arcano talking to the representatives in the Maritime Information Technology Center about doing that by creating new relationships and strengthening existing ones. Jack Templeton, chief technology officer at Carderock, then presented an overview of Carderock Division, including its mission, location, personnel, command structure and funding.

"When you reach into any of these laboratories, you're reaching into a greater community of laboratories," Templeton said. "Carderock is one of 10 Naval Surface and Undersea Warfare Centers; and it's part of a greater Naval Research and Development Establishment. At Carderock specifically, we are Navy mobility systems and the integration of the platforms and payload that will deliver an asset to the fleet. Our vision is to be the trusted partner for the Navy to realize that goal."

Dr. Walter Jones, executive director of ONR, followed with the keynote speech, giving a similar breakdown of ONR. After these speeches, representatives separated for parallel technical sessions, and then tours of Carderock, including the David Taylor Model Basin and the Manufacturing, Knowledge and Education (MAKE) Lab. Dr. Larry Schuette, the director of research at ONR, spoke to the academics on how to work with ONR while in collaboration with the NR&DE. These were followed by a brief on doing business with Carderock, explaining contracting, human resources and other logistical concerns, and finally, a discussion on models for partnership between academia and Carderock with Barkyoumb.

"In a lot of these cases, these university professors want to work with us," Barkyoumb said. "They see some mutual research. Then when they start, they don't know that there are programs they can work in that will help that research get done and maybe even provide money or structure to do it. When they start doing it, we may find agreements that we don't have in place, like Cooperative Research and Development Agreements (CRADAs), that after hearing this, they may know to approach someone like me or Dr. Joe Teter (Carderock Division Technology Transfer Office director) to ask about how to enter one of these agreements."

The day concluded with another round of breakout sessions, this one focused on models for collaboration and facilitated by Carderock's human-centered design team. Participants split up to brainstorm and write ideas on sticky notes about current and future technology and Navy-academia collaborations, classify those ideas and then regroup and report their findings. Nathan Hagan, a naval architect with the Structural Criteria and Risk Assessment Branch who led one of the sessions, said this provided an interactive activity and opened up dialogue between the Carderock and academic sides.

> "The goal would be closer collaboration [with academia]that speeds the transition of our technology and technology from the universities to the fleet and warfighter."
>
> - Dr. John Barkyoumb,
> Carderock Division director or strategic relations

"The purpose of human-centered design is to solicit information from a user base in a very organic fashion, and then from that, associate it and make connections so you are able to identify bigger trends and things that might shape decisions," Hagan said. "All of the data that was collected during those exercises will be utilized by Dr. Barkyoumb and the command in making recommendations for how to proceed, whether it be improving existing collaboration processes or adding a new one that doesn't exist yet."

Dr. Matt Wolfe, a scientist and leader of the Futures team at Virginia Tech Applied Research Corporation (a not-for-profit liaison for Virginia Tech), was visiting Carderock for the first time after his company heard about the event from one of their government partners. He said he enjoyed touring Carderock and that the event provided both exposure to the breadth of work done there and ample networking opportunities.

"The Navy, like most government institutions, cannot possibly work in isolation due to funding, efficiency and bureaucratic challenges," said Wolfe, who earned his Ph.D. in biochemistry from the University of Minnesota. "Partnering with academia can yield large gains from modest investments in funding, publications, new ideas and technology development. Each party stands to gain, because the one thing that Navy and academic researchers have in common is their academic training."

Barkyoumb said the interaction and exchange of ideas between Carderock's employees and the academics made the event a success.

Students, professors and Carderock engineers discuss future of naval warfare

By Dustin Q. Diaz, NSWCCD Public Affairs

Naval Surface and Undersea Warfare Center Executive Director Don McCormack (at podium) greets guests at the Naval Engineering Education Consortium annual event held at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., April 19, 2016 (U.S. Navy photo by Monica McCoy/Released)

Engineering students and their professors from universities nationwide discussed the future of naval warfare with engineers at Naval Surface Warfare Center, Carderock Division, April 19.

The Naval Engineering Education Consortium's (NEEC) annual event gave students from 23 universities the forum to present projects that address real-world Navy problems, as well as talk about how and why to join the Naval Sea Systems Command (NAVSEA) workforce. NEEC is a NAVSEA-directed program carried out at all 10 NAVSEA Warfare Center divisions to cultivate a world-class naval engineering workforce through student participation in project-based research at colleges and universities.

Keynote speaker Vice Adm. David C. Johnson, principal military deputy to the assistant secretary of the Navy for research, development and acquisition, discussed NAVSEA's work and why the students should want to be a part of it.

"We offer work which you'll get nowhere else – challenging work and responsibility well ahead of your peers in industry," Johnson said. "The Navy offers great opportunities to further your education and be right in the mix of technology and development, seeing where it's going and what our nation needs. You can work with stuff like railguns, lasers, hypersonics, missiles, unmanned and autonomous vehicles, sonar, radar, electromagnetics, optics, aircraft, ship and submarine design, just to name a few.

"And this work: it matters. There is a Sailor or a Marine out there who will use or is using the technology that you developed keeping our nation secure. We do live in an uncertain world and naval engineers are responsible for engineering the armament of the current and future force. There really is no more important work," Johnson said.

The students in attendance, who are pursuing engineering degrees from

participating institutions like Virginia Tech, University of Maryland and Old Dominion University, presented projects they worked on in teams that also included their professors and technical mentors from the Warfare Centers. This is in line with one of NEEC's primary objectives of acquiring academic research results and products to resolve naval technology challenges.

"We are building a computational model to characterize an advanced material, trying to quantify how the different inputs to the manufacturing parameters affect your final material properties," said Elijah Stevens, a graduate student leading a team at University of Tennessee-Knoxville presenting the "Integrated Simulation and Testing for the Qualification of Composite Parts Fabricated Through Additive Manufacturing (AM)" project, which relates to the 3-D printing work done at Carderock and other Warfare Centers. "AM systems are extremely sensitive, and the way the Navy chooses advanced materials requires a lot of testing. That could be very expensive to explore all the different permutations you could go through, but if you have a good model, you can use it to narrow down all your good candidates and do your expensive mechanical testing on likely systems that would work the best."

Other projects presented included dynamic biometric sonar, pollution control and other areas where the Navy has a problem to address or areas to improve. Stevens said his academic adviser put together a proposal for NEEC that he decided to get involved with due to his interest in AM.

"It's probably one of the coolest technologies out there right now," Stevens said. "There's so much that's not understood, and it's so interesting. I find that challenge to be a draw. If we can solve these challenges, it'll be really useful to the Navy."

Another of NEEC's objectives is to hire college graduates with naval engineering research and development experience. A human resources specialist explained the federal hiring process, and a panel of engineers answered questions from the students about their experiences joining and working for NAVSEA. Being involved in NEEC lets students get that experience before actually becoming an employee, according to NAVSEA Chief Technology Officer Kirk Jenne, who organized the conference.

"Think about it as a continuum of people throughout their careers," Jenne said. "You have fresh talent in the workforce now who will develop throughout their careers and then become more mature and senior in an organization. Eventually they will retire. What we're doing with NEEC is reaching outside of the organization at the far-left time scale of this continuum to prime universities to help us train the best students and bring them into our workforce. This initiative is critical to sustaining an innovative and technology-savvy workforce for national security."

The third objective of NEEC is to develop and continue exceptional working relationships among naval engineering colleges, universities, professors and academics. Pierre Valdez, a graduate student at University of Tennessee-Knoxville, who presented the project "Design and Implementation of Communications-constrained Path Planning Algorithm for Unmanned Vehicles Operating in Littoral Environments," said NEEC has done that for him, partly through his experiences working as an intern at Naval Surface Warfare Center, Panama City Division through the Naval Research Enterprise Internship Program. He said he keeps in regular contact with his mentor, who gave him the idea for his thesis for his doctorate.

"The Navy has a lot of cool stuff going on that I want to be involved with," Valdez said. "I love autonomous and unmanned vehicles. I love working on them, and I can see how they can be a solution to many of the problems the Navy is facing. I like the Navy's approach to research, and I think I will work for the Navy in the future."

After their presentations, students learned more about Carderock Division's technical capabilities by touring some of its facilities, including the David Taylor Model Basin, the Maneuvering and Seakeeping (MASK) Basin and the Structures and Survivability Lab.

Other speakers at the meeting included Don McCormack, executive director of the Naval Surface and Undersea Warfare Centers; Rear Adm. Lorin Selby, then commander, Naval Surface Warfare Center; Dr. Hardus Odendaal, a professor at Virginia Tech; and Jack Templeton, chief technology officer at Carderock.

For more information on NEEC, visit www.navsea.navy.mil/Home/WarfareCenters/Partnerships/NEEC/AboutNEEC.aspx.

Participants of this year's Naval Engineering Education Consortium annual event tour the model fabrication shop at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., April 19, 2016 (U.S. Navy photo by Monica McCoy/Released)

WAVES is an official online publication of Naval Surface Warfare Center, Carderock Division and is approved for public release.

Naval Surface Warfare Center, Carderock Division
9500 MacArthur Blvd.
West Bethesda, Maryland 20817-5700

Website: www.navsea.navy.mil/Home/WarfareCenters/NSWCCarderock

Like us on Facebook:
www.facebook.com/CarderockDivision

Follow us on Twitter:
www.twitter.com/nswccarderock

Follow us on Flickr:
www.flickr.com/nswccarderock

Subscribe to our YouTube Channel:
www.youtube.com/NSWCCarderock

NAVSEA
WARFARE CENTERS
Carderock