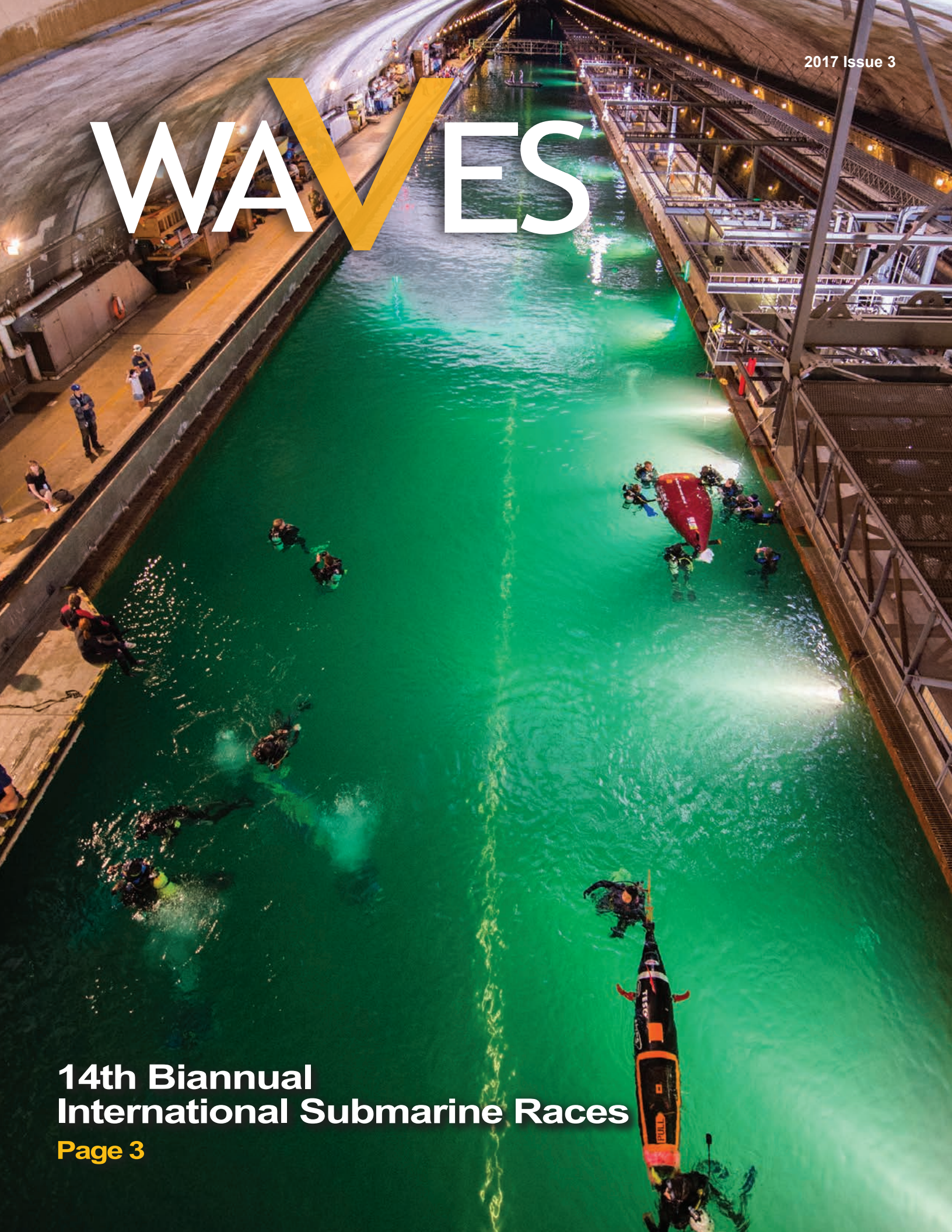
2017 Issue 3

WAVES



14th Biannual International Submarine Races

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I've had the pleasure of serving as the acting technical director for these last two months, and the technical excellence at Carderock never ceases to amaze me. As I read through the stories in this issue of Waves, I can't help but be proud to work with such a talented workforce.

Carderock hosted the 14th biennial International Human-Powered Submarine Races (ISR) this year, when 23 high-school and college teams from all over the world came to race their submarines. This issue has a special section dedicated to ISR, and you can read an overview of the races (Page 3); about the Navy divers who ensured the safety of the racers (Page 6); the history of submarines, specifically the Confederate Sub H.L. Hunley, which was the first submarine to successfully sink an opposing ship (Page 10); and some of the dedicated employees who not only helped make these races a success, but also participated in them when they themselves were in college (Page 8).

As long as I've been working for the Navy, I can tell you that collaboration has been at the forefront of our work, whether it's collaborating with other Warfare Centers, labs, services or academia. This issue of Waves showcases several times when Carderock has partnered with other organizations to come together for a common goal, such as the testing of the Coast Guard's icebreaker model in one of Canada's ice tanks (Page 14). Our Little Creek detachment, Combatant Craft Division, worked with students and professors from Old Dominion University in Norfolk to help them develop an unmanned vehicle (Page 26). Our "wave makers" worked with the Department of Energy again to test a wave energy converter that could very possibly bring portable energy to warfighters at sea (Page 22).

It's no surprise that collaboration and partnerships take up so much space in our magazine. It just continues with additive manufacturing. The Marines held their final Marine Corps Innovation Challenge at Carderock, and with the help of our Manufacturing and Knowledge Education (MAKE) Lab experts, Marines developed products that other Marines will be able to use on the battlefield (Page 32). These experts also worked hard over a holiday weekend to print a large number of a necessary part for Navy aircraft in order to allow them to fly missions (Page 12).

I don't think I even covered half of the great stories that are in this issue of Waves. My rotation as the acting technical director is ending, and I will I go back to leading the Ship Signatures Department full time. I'm very happy to have had this opportunity, as it really makes me remember to look at the big picture of what we do here at Carderock. And it's a pretty amazing picture.

All the best and enjoy Waves,

Dr. Paul Shang
Acting Technical Director
Head, Signatures Department

Cover

Naval Surface Warfare Center, Carderock Division hosts the 14th International Human-Powered Submarine Races in the David Taylor Model Basin in West Bethesda, Md., June 25-30, 2017, featuring 23 teams from universities and high schools. (U.S. Navy photo by Devin Pisner/Released)

Team

Dr. Paul Shang
Dustin Q. Diaz
Katie Ellis-Warfield
Roxie Merritt
Kelley Stirling
Kevin Sykes
Margaret Zavarelli

Carderock sub races draw worldwide teams, promote STEM

By Daniel Daglis, Carderock Division Public Affairs

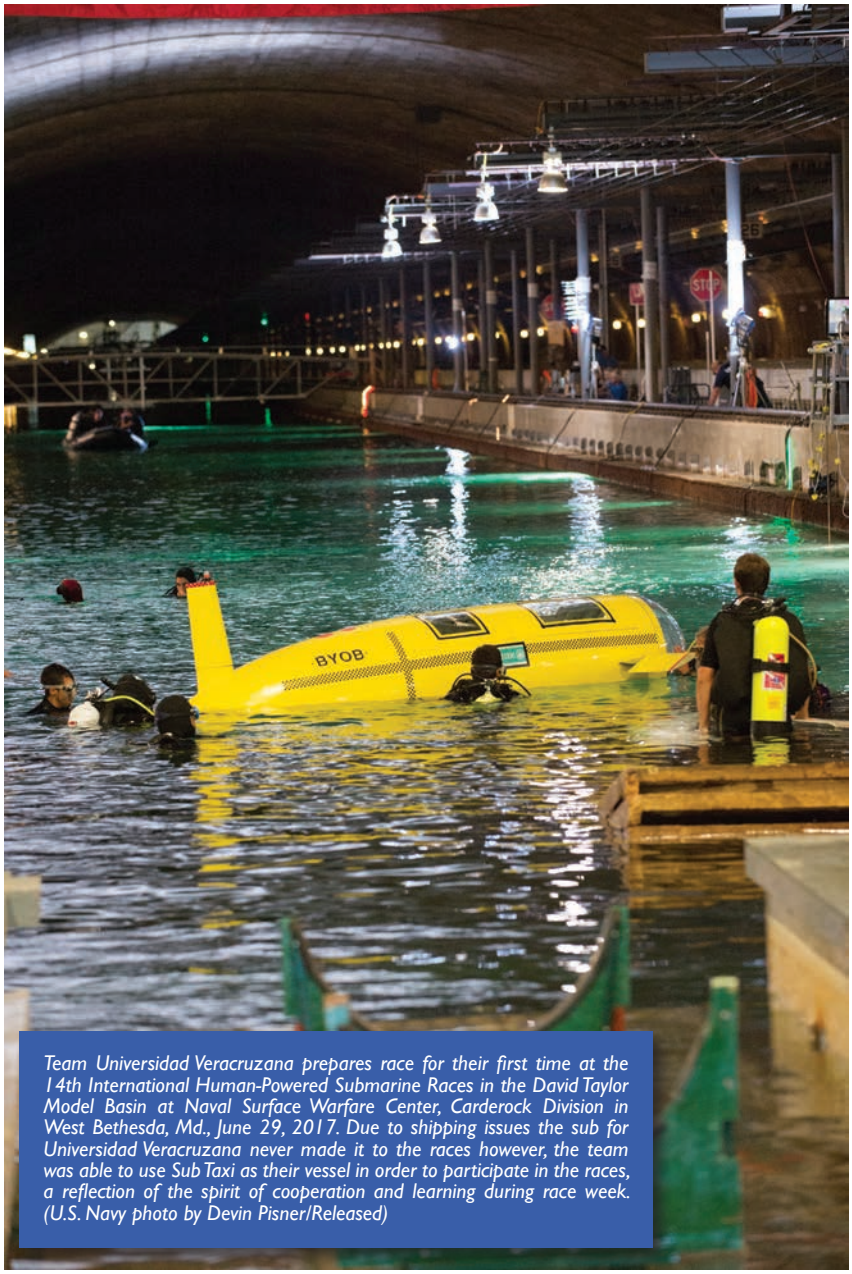
Students of engineering from universities and organizations across the country and abroad converged at Naval Surface Warfare Center, Carderock Division in West Bethesda, Maryland, for the 14th biennial International Human-Powered Submarine Races (ISR), June 25-30.

Human-powered submarines in the shape of everything from a shark to an ice cream cone with all the fixings were raced by 23 participating teams in the 1,886-foot Deep Water Basin, which is just one of the three sections that make up the 3,200-foot-long David Taylor Model Basin building at Carderock.

The ISR has been a premier science, technology, engineering and math (STEM) event for 28 years; it is sponsored by the Foundation for Underwater Research and Education (FURE) and hosted by Carderock, the Office of Naval Research and Program Executive Office Submarines. ISR challenges students to design, build and race a one- or two-person human-powered submarine on an underwater course. Former Carderock commanding officer and current president of FURE, retired Navy Capt. Charles Behrle, said the David Taylor Model Basin has proven to be the perfect environment for the races over the years.

"The first races were held off the coast of Florida in the surf," Behrle said. "One of our biggest concerns with ISR is safety for the participants, so when you're in the surf and the winds pick up and the seas pick up, it makes it more challenging. One of the final races they had down in Florida was almost completely all blacked out because of weather. The Basin came up in planning discussions and the Navy agreed to host the event, which is great because it provides us with a safer indoor facility that can accommodate up to 25 or 30 teams."

The inaugural race was held in June 1989 at Riviera Beach, Florida, born from a concept developed by the H.A. Perry Foundation and Florida Atlantic University's Department of Ocean Engineering, before coming to the David Taylor Model Basin in 1994. According to Behrle, the first race in Florida proved very successful, with 19 teams from academic institutions, corporations and independent groups gathered to race their submarines and test their designs.



Team Universidad Veracruzana prepares race for their first time at the 14th International Human-Powered Submarine Races in the David Taylor Model Basin at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 29, 2017. Due to shipping issues the sub for Universidad Veracruzana never made it to the races however, the team was able to use Sub Taxi as their vessel in order to participate in the races, a reflection of the spirit of cooperation and learning during race week. (U.S. Navy photo by Devin Pisner/Released)

"This is the event that brings everything together. The participating students have had the classroom, they've had the theory

All participating teams in the 14th International Human-Powered Submarine Races pose in front of the David Taylor Model Basin at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 29, 2017. (U.S. Navy photo by Devin Pisner/ Released)

and they've done the calculations. What ISR adds is the actual human factor, as well as the 'What could go wrong?' factor," Behrle said with a laugh. "Sometimes things don't go the way the numbers say they should; the next step is focusing on how to fix it.

"Some of these teams don't get into the water until they're here. So if they're lucky, they've gotten in the water in an Olympic-size pool somewhere and at least submerged their sub, but some of them show up never having gotten in the water with that particular boat. So there are things that may not go as planned. It may not go as the book said it should, so now they're into the real world of 'How do I change it? What do I learn? How do I fix it?' Some of the teams are extremely well-equipped with respect to the materials and tooling to do that kind of thing on site, some of them less so. What's always very good to see is the teams help each other out. Yes, it's a competition and they all want bragging rights, if a team is lacking something or needs something repaired to get into the basin and have a successful run, the other teams hover around and help. Whether it's providing bodies, materials or expertise, it's a huge collaborative effort and learning experience for all involved."

Today, the races have proven an international success, with participating teams from Germany, Mexico, the United Kingdom, Canada and the Netherlands. Universities including the University of Michigan, Virginia Tech, the University of Washington and even some high schools including Sussex County Technical School in Sparta, New Jersey, and Mosley High School in Lynn Haven, Florida, participated in this year's races. Also participating was an independent group from Accokeek, Maryland, called Kids into Discovering Science that started as a family affair, grew into mostly home-schooled children and is now flourishing with participants from grade school through college. ISR is open to all institutions or groups that want to participate.

While getting through the underwater obstacle course as quickly as possible might seem like the goal, the fastest time is far from the only facet of ISR. There are 16 judges throughout the week assessing and inspecting the work of the teams including the design, safety and overall process for making improvements on the submarines.

A trophy and $1,000 award sponsored by Booz Allen Hamilton is awarded to the submarine team from any design category that displays the best overall performance, determined by a figure of merit which takes into account the team's attitude, persistence and resourcefulness.

Other award categories include Absolute Speed, Fastest Speed by Category, Innovation, Best Design Outline, Smooth Operator and Best Spirit of the Races.

"You'll note that with the awards we do a top overall, but then there's also an innovator award, and we look for innovations in a team's design," Behrle said. "That's something that we highly seek in what they're doing because it means they're thinking outside the box, and it's a mentality that all great engineers have. We put all those design reports in a compendium, and then we mail each team a disk and make it available on our website, so a fledgling team can see all these reports and get an idea of how to construct theirs, but also get ideas about what's been tried before."

The record for top speed in the history of the races for any design is 7.4 knots. According to retired Carderock engineer and long-time volunteer and member of the FURE Board of Directors Dan Dozier, most of the submarines compete in the 5- to 6-knot range, which Dozier said is up significantly from the past. However, as Dozier noted, it is not always about being the fastest.

"Some teams aren't going for maximum speed, they're striving to have the best new innovation," Dozier said. "Propellers are very efficient, but there are a lot of teams that are trying some non-propeller propulsion, for example, using oscillating foils or wagging tails. So it's not always about going for the world record, it's about using your imagination, knowledge and skills as an engineer to come up with something new and effective."

Dozier and Behrle are just two of the 77 volunteers who work to make ISR a success. Behrle said that all of the volunteers are not just contributing the week of the event, a lot of them spend their time throughout the year coordinating with schools, showing up at school cafeterias and contacting university naval architecture programs to join in the races.

Currently, there are more than a dozen engineers working at Carderock that have previously participated ISR. Danielle Kolber and Charlotte George are two past participants and engineers in Carderock's Center for Innovation in Ship Design who contributed as principal organizers for this year's races. Behrle said that while ISR is designed to be fun, it has truly become a venue to get students excited about engineering and gives them the experience and encouragement to pursue careers in STEM.

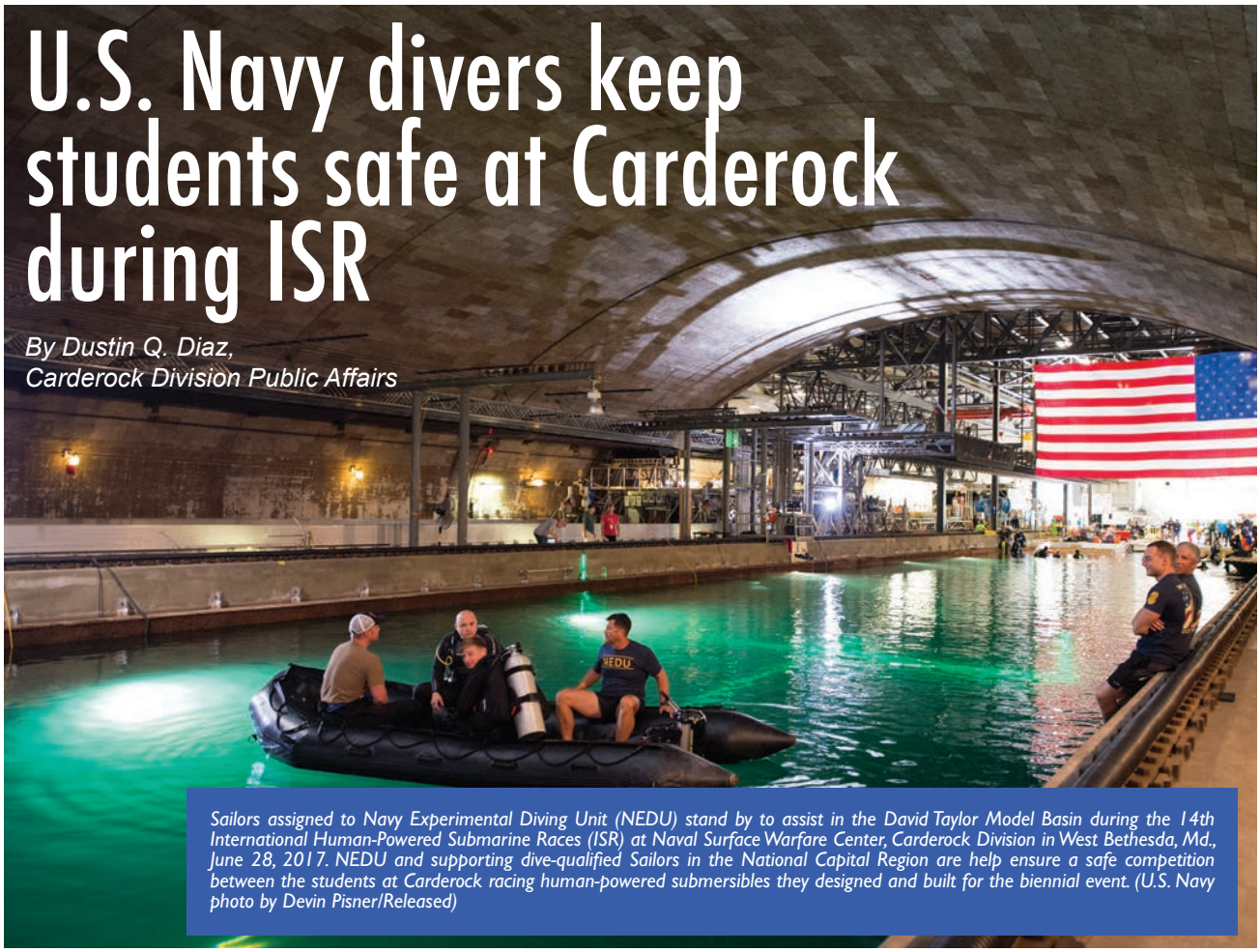
For more information about FURE and the ISR, visit www.internationalsubmarineraces.org.

To see photos of the races on Carderock's Flickr page, visit https://www.flickr.com/photos/nswccarderock/albums/72157682622255494.

Several teams prepare to race on day two of the 14th International Human-Powered Submarine Races in the David Taylor Model Basin at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 27, 2017. (U.S. Navy photo by Devin Pisner/Released)

U.S. Navy divers keep students safe at Carderock during ISR

By Dustin Q. Diaz,
Carderock Division Public Affairs



Sailors assigned to Navy Experimental Diving Unit (NEDU) stand by to assist in the David Taylor Model Basin during the 14th International Human-Powered Submarine Races (ISR) at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 28, 2017. NEDU and supporting dive-qualified Sailors in the National Capital Region are help ensure a safe competition between the students at Carderock racing human-powered submersibles they designed and built for the biennial event. (U.S. Navy photo by Devin Pisner/Released)

Every other year, hundreds of college and high school students come from around the world to Naval Surface Warfare Center, Carderock Division (NSWCCD), to race human-powered submarines they designed and built themselves in the command's David Taylor Model Basin (DTMB). Sailors assigned to the U.S. Navy's primary source of diving and hyperbaric operational guidance were on station in the basin during the 14th International Human-Powered Submarine Races (ISR) in June 2017, ensuring the most important part of the race – safety – is maintained in this high-stakes environment.

"This event is inherently dangerous because of what can happen during the races," said Chief Explosive Ordnance Disposal Technician Ralph Schmitz, special warfare diving leading chief petty officer for Navy Experimental Diving Unit (NEDU). "The students competing in this event are underwater in their craft during this race. If their primary air source (scuba) fails when you're in 20 feet of water, what do you do? For us, dealing with a situation like that is almost second nature. It's what we do."

NEDU, homeported in Panama City, Florida, is the Navy's leading center for diving research, development, and testing and evaluation, also providing physiological and engineering solutions for undersea operations. The command comprises more than 120 highly qualified and experienced active duty, civilian and contract personnel from all diving communities: Sea, Air, Land (SEAL); Explosive Ordnance Disposal (EOD); salvage; saturation; Seabee; engineering duty officer; and undersea medical officer. Previously existing relationships between Carderock and NEDU personnel made a working relationship easy to establish for this event, according to NEDU Commanding Officer Capt. (Sel) Jay Young.

"Our executive officer Lt. Cmdr. Junior Lorah participated in this event in prior years at another duty station, so he knew Charlotte George (Carderock head liaison for ISR) already. Fast forward to 2017, she called us with the event coming up and asked if we could help with the dive side, and we said, of course we want to support," Young said. "I've known Carderock Commanding Officer Capt. Mark Vandroff for 15 years, so I called him up offering to have NEDU run the show, and he said, 'Absolutely, I don't need to ask any more questions.' With NEDU and Carderock both under NAVSEA (Naval Sea Systems Command), this allows us to strengthen our relationships in the NAVSEA family, as well."

Schmitz and Lorah planned and prepared for ISR for months, regularly coordinating with Carderock liaisons to receive information about the area, facilities and event, and discussing their capabilities and what they could or could not do to support.

Chief Navy Diver Justin Griffin (left) and Navy Diver 1st Class Stephen Eide, both assigned to Navy Experimental Diving Unit, talk to U.S. Rep. Rob Woodall of Georgia and U.S. Rep. Tom Rice of South Carolina about their responsibilities during the International Human-Powered Submarine Races at Naval Surface Warfare Center, Carderock Division, in West Bethesda, Md., June 26, 2017. U.S. Rep. Chris Stewart of Utah, not pictured, also visited the races. (U.S. Navy photo by Devin Pisner/Released)

"The flow of information was really good. We were able to dial in and make sure we knew exactly what they expected, and now we're here to deliver," Schmitz said. "We've worked with the race directors and folks at Carderock before – the links and liaise was already developed. We have first-class divers we bring, EOD divers with a lot of experience and medical staff dedicated to underwater medicine. We have all the capabilities you need to support this event in one package, and we're happy to be asked to contribute."

Once at the basin and in the water, the NEDU divers, with support from other active duty and reserve dive-qualified Sailors in the National Capital Region, took responsibility for the race course area of the DTMB, while the ISR staff and divers were responsible for the launching area.

"When they break the plain of the green lights at the start of the race course, from that moment until they either fail or successfully complete the run and are extracted, we have total control of the evolution," Schmitz said. "There's a lot that can go wrong working in this environment with the level of training and experience many of these students have.

"We've worked closely with the race coordinators, who have done this 13 times before, so we don't question their judgment; they're really good at what they do. We're very adaptive and we take direction well, so it's been very easy for us to get accustomed to the environment quickly and just get on board with the rest of the team making this event happen safely."

Young said NEDU takes a proactive approach to planning and safety and is well-suited to support ISR because of the diversity of commands NEDU works with like the Office of Naval Research and Naval Special Warfare, their breadth of experience operating in unconventional environments and the knowledge the unit has from testing all diving equipment for use in the Navy, as well as its ability to react quickly and decisively in case of a mishap.

"The diving we do at NEDU is some of the most complex diving that anybody does, we are always putting ourselves in the hairy edge of what divers can and can't do," Young said. "We go above and beyond pressing the envelope for higher efficiency diving, new equipment, better human performance to improve military diving throughout the world. It is our hope that we can keep this relationship and continue to proudly provide this support to ISR in 2019, 2021 and beyond."

Schmitz praised his team of divers working at ISR and said being a part of the event was a fun change of pace for him and something he's happy to work on.

"This is a special facility, so to have access to it and work to support these students who are entertaining themselves with this contest, but also participating as a military member in something that will benefit our civilian counterparts while contributing to research that will ultimately benefit the military – well, it's the kind of thing that's a once-in-a-lifetime experience," Schmitz said. "We've met some very interesting people at this event, from astronauts to flag officers to congressmen, and I'm glad to give my Sailors that kind of visibility. It's a privilege and very humbling to be responsible for a vast portion of what NEDU is doing here to support."

For over 25 years, the Foundation for Underwater Research and Education (FURE) has sponsored ISR as the capstone science, technology, engineering and math (STEM) event for thousands of young men and women. According to FURE President Charles Behrle, a former commanding officer at Carderock, this biennial design competition for human-powered underwater vehicles, hosted by NSWCCD since 1995, provides valuable educational experiences to the best and brightest engineering and science students throughout the world.

Carderock employees were past ISR participants

By Dustin Q. Diaz, Carderock Division Public Affairs

Danielle Kolber

Danielle Kolber is a naval architect with Carderock's Center for Innovation in Ship Design (CISD). This year was her first time supporting the International Submarine Races (ISR) as a Carderock employee and co-liaison with the Foundation for Underwater Research and Education (FURE), but she's been involved with the event since 2009.

"I'm helping with ISR due to being a past racer," said Kolber, who graduated from Florida Atlantic University (FAU) with a bachelor's degree in ocean engineering en route to becoming a Carderock employee. "It was a great experience in general, and I wanted to continue seeing ISR grow and evolve."

Kolber's first involvement with the event came about while she was a student, competing in the event as part of the FAU team. She said the networking opportunities at the event led to friendships, study groups and other networking opportunities that made her want to stay involved ever since. She later returned to Carderock as an intern under the Naval Research Enterprise Internship Program and continued her involvement with ISR.

Kolber became a Carderock employee in 2015, joining CISD so she could work on different things on a rotational basis. She's been involved with experimental engineering and testing, as well as additive manufacturing during her time at Carderock, and this summer, this prior intern supervised this year's group of Science and Engineering Apprenticeship Program interns as they work on three naval architecture projects and an environmental project.

Kolber said she learned about Carderock to begin with through the command's partnership with FAU and that she wanted the opportunity to work at the command's state-of-the-art facilities. Since she's been aboard, Kolber said she has fallen in love with the atmosphere, the community and working on the Navy mission.

"I do a lot of tours and STEM outreach – that's big at Carderock and I try to help out," Kolber said. "I think giving back is something that's really important to inspire the next generation. That's another reason I stay involved in ISR, too. It's something near and dear to me and I want to do what I can to keep it going. To be able to do that as an employee here is definitely coming full circle."

Kolber said as a new employee, she's just getting started at Carderock. She said she has plenty of goals for the future, from a continued focus on naval architecture to experimental engineering and augmented reality, and is in the perfect place to do it.

Charlotte George

Charlotte George is a CISD member serving as a Carderock co-liaison at the 14th ISR and has been involved with the event since 2009. This is her third time involved as an employee in Carderock's largest STEM outreach event, the same one that led her to begin working here after her interest was piqued at that event eight years ago.

She first participated in ISR as a sophomore at FAU after joining the school's sub club on a teacher's advice. "The teams try to keep freshmen on the team to retain a knowledge base so there's continuity when the seniors graduate and they don't take all the knowledge with them, so I was one of the younger people that they pulled in to start working on FAU's sub club," George said.

George joined a team in the finishing year of their project for the next ISR five months before the event. She contributed her organization and documentation skills in the latter stages of their preparation. "They want you to build a submarine and race it, document everything and then present it, because an engineer does all those things," George said.

When her team was short-staffed, she served as the lone presenter for her team at ISR in 2009. "At the last minute, I got thrown to the wolves and presented our submarine design to the ISR judges, which typically includes Carderock employees." Afterwards, one of the judges (a Carderock employee) spoke with her about his career at NSWCCD and the hydrodynamic research conducted at Carderock. It was this conversation that made her interested in the engineering work done to support the mission.

"After the race, I looked into an internship with Carderock, which was always an option thanks to the relationship with FAU, but I'd never considered it. That's how I got set up through NREIP and did my NREIP internship the next summer with CISD," George said. "I was awarded the DOD SMART (Science, Mathematics and Research for Transformation) scholarship for my senior year, so I came to work here after I graduated in 2012."

Now a Carderock employee for five years, George's job as a naval architect in CISD supports the Columbia-class submarine program, concentrating in development of model scale instrumentation. This includes work towards integrating

dynamometry measurements in two models: the Very Large Test Apparatus which is operated at the Memphis detachment's Large Cavitation Channel, and the Large Scale Vehicle which is operated at the Bayview, Idaho, detachment. Along with ISR, she also supports the Carderock Math Contest and other STEM outreach efforts.

Gregory Nelson

Gregory Nelson describes his initial experience as a student at the University of Michigan with the ISR as one of excitement and accomplishment.

"I was the sub team manager for the University of Michigan-Ann Arbor from 2005-2007. I restarted a disbanded team the winter before my first race that refurbished their existing submarine to get it ready for competition. This involved fundraising, recruiting, design, manufacture, logistics, testing and, of course, racing activities," said Nelson, who graduated with a B.S.E. in naval architecture and marine engineering after his second ISR. "I loved the challenge of running what was effectively a micro-scale business enterprise. The sub team gave me an outlet on which to practice the science I learned in the classroom."

Nelson is now a supervisory engineer in the Frigate Program Office of Carderock's parent command, Naval Sea Systems Command (NAVSEA), at the Washington Navy Yard. His job is to participate in and supervise an assortment of ship acquisition activities performed by programmatic and technical team employees. Participating on the sub team, Nelson said, gave him a strong appreciation for the delicate balance between cost, schedule and technical considerations, all of which need to be properly addressed in order to achieve program success, either on the sub team or in the work environment. It also prepared him to transition to the workforce.

"The personal, technical and business skills I learned while participating in the sub races set the foundation for the beginning of my career," Nelson said. "I attribute the confidence I had in my first round of job interviews to my experiences on the Michigan sub team because it gave me interesting, job-related technical experiences to talk about when asked otherwise awkward interview questions."

Nelson said his positive experience at ISR made him feel even more confident in his decision to pursue a career in ship design and acquisition with the Navy. The highlight for him, though, was taking part as a diver while also managing during his first ISR.

"It was the most memorable part of my education: the tingling feeling I got being in the water, either as the pilot or a support scuba diver, and watching the propellers start running," Nelson said. "The ISR is incredibly well-run by an expert team and to anyone interested in participating, I say do it!"

Kariann Vander Pol

Kariann Vander Pol, an aerospace engineer with Carderock's Criteria and Assessment Branch, spent time diving in the David Taylor Model Basin as part of her responsibilities with the Virginia Tech team.

"I was on the team for the 2013 competition. Although my classes prevented me from coming to Carderock that year, I helped pack up the sub before the team left Blacksburg," said Vander Pol. "I did travel with the subs to the 2015 competition and had gotten scuba-certified to help while the submarine was in the water. I was lead of the team in charge of the control surfaces for the 2015 competition."

Vander Pol said she enjoyed the high stakes of the competition. After the two years they'd put in working on that sub, the team did what they needed to make things work on the day of the competition, including many late-night hardware store runs leading up to it. One of her fellow classmates was interning at Carderock under the (SMART) scholarship program during the competition, leading Vander Pol to pass on her resume to her friend for consideration for employment at Carderock. By the end of competition week, she'd secured an interview with the Structures and Composites Division head, and by the end of the year, she had transitioned from student and ISR contestant to Carderock employee.

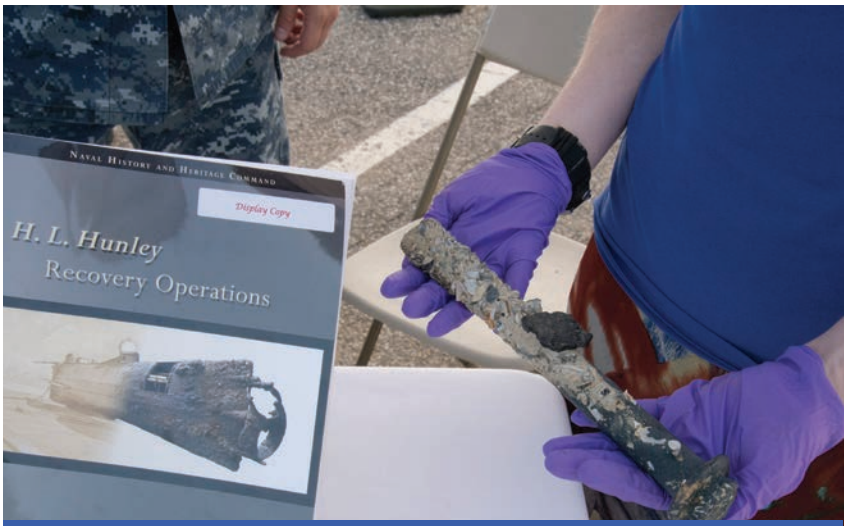
"I think Carderock was interested in me because of my composite materials experience that I only got from being on the ISR team at Virginia Tech," Vander Pol said. "We had laid up a hull by hand leading up to the competition and that experience has helped me in my job."

Today, Vander Pol remains involved as an employee of the command that hosted the event that first garnered her interest in working there. She now supports ISR as a volunteer and said she still benefits from her own time as a visiting student at Carderock, working outside the classroom as part of a team toward a meaningful common goal.

"I've been working with (Carderock ISR head liaison) Charlotte George to help things go smoothly during this year's event, but during the slow periods it's nice to walk around and see the designs the students create and watch the races," Vander Pol said. "I think the ISR competition as a whole is awesome! It's always fun when a sub makes it across the finish line for the first time because I've seen how much work it can take to get there."

Carderock welcomes NHHC to sub races, educates participants on the H.L. Hunley

By Dustin Q. Diaz,
Carderock Division Public Affairs



Heather Brown from the Naval History and Heritage Command (NHHC) holds an artifact found from the remains of the Union ship USS Housatonic, which was sunk during combat by the Confederate submarine H.L Hunley on Feb. 17, 1864, at the 2017 International Human-Powered Submarine Races held in Naval Surface Warfare Center, Carderock Division's David Taylor Model Basin in West Bethesda, Md., June 25-30. (U.S. Navy photo by Daniel Daglis/Released)

At Naval Surface Warfare Center, Carderock Division, students of engineering from around the world participating in the 14th biennial International Human-Powered Submarine Races (ISR) June 25-30 in the historic David Taylor Model Basin in West Bethesda, Maryland, were enlightened on the historical significance of the human-powered submarine.

Personnel from the Naval History and Heritage Command (NHHC) were on site talking to participants, race guests and Carderock staff about the mystery that surrounds one of the Navy's first human-powered submarines: H.L. Hunley.

According to Heather Brown, NHHC historian and co-author of the book "H.L. Hunley: Recovery Operations," Hunley – officially part of the Confederate Navy built in 1863 by Parks and Lyons of Mobile, Alabama – was the first sub in U.S. history to sink an enemy warship in combat.

"There was a cordon of Union vessels blocking access to Charleston, South Carolina, in an effort to try to strangle off merchant shipping, so Hunley targeted one of those ships that was easier to get to, USS Housatonic," Brown said.

Like the submarines built and raced during ISR, Hunley was human-powered. A product of its time, Brown noted that this was the only efficient way to power a submarine because at the time the primary artificial mode of propulsion was steam power, which would not work in an underwater environment. Hunley was operated by a seven-man team on a central crank shaft with an eighth man to pilot.

"On Feb. 17, 1864, they cranked out to sea four miles and they had a spar-mounted torpedo – today's equivalent of a mine – fixed on a spar that was 16 feet long that came out from the bottom of the bow. With this they rammed into the side of Housatonic and the explosive detonated and sank the ship in about five minutes. The water was very shallow so the rigging was still sticking up out of the water of Housatonic, so most of the men were able to climb up and get above the water."

Five men aboard Housatonic died from the explosion, but it would be the fate of the men in Hunley that would remain a mystery until recent decades. According to Brown, after the attack, Hunley just disappeared.

"There was over 100 years of speculation about what happened to it and a lot of people had been looking for it since then, and they did find it using a magnetometer survey. It was buried 3 feet under the seabed at that point in 1995 when they found it off the coast of South Carolina, only about 800 feet away from wreckage of Housatonic – so it didn't get very far."

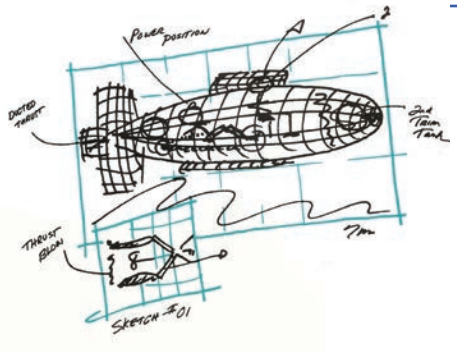
Brown said some speculated the crew of Hunley might have been trying to get out of the way of an incoming ship so they were not hit or spotted; others have speculated that it wasn't ebb tide at the time and the sub was lost out to sea while waiting for the flood tide to start coming in so they could get to shore.

To help understand the mystery of what caused Hunley to sink immediately after it carried out the attack on Housatonic, engineers from several Warfare Centers, including Carderock, used advanced digital modeling and simulation techniques to study the effects of the explosion on Hunley and its crew, and the hull's seagoing characteristics. The exact cause of Hunley's sinking is still a mystery.

According to literature provided by NHHC, Hunley was hoisted from the depths of the sea in the summer of 2000, finally completing its voyage back to Charleston for preservation and examination. Brown and Mass Communications Specialist 1st Class Cliff Davis shared with visitors an artifact from Housatonic that was pulled from the remains of the ship after some minor excavation of what remains of the vessel.

The human-powered submarine in one- and two-person designs has remained a staple of ISR. NHHC staff explained a brief history of the evolution of the Navy's submarines. Davis pointed out that Hunley had an average speed of 4 knots, while many of the submarines designed by the students operate within the 5- to 6-knot range, a true testament to the advancements in engineering and the capabilities of the students involved with the races.

Results of the 14th International Submarine Races, June 25-30, 2017



Overall performance

A trophy and $1,000 award is given to the submarine team from any design category that displays the best overall performance. The ranking of Overall Performance is determined by quantifying the Figure of Merit for each team and submarine. Seventeen weighted parameters are ranked. The analysis includes aspects of other awards and the team's attitude, persistence and resourcefulness. This award is sponsored by Booz Allen Hamilton.

- Winner: OMER X – Ecole de Technologie Superiere (University of Quebec), in Quebec City, Quebec, Canada

Innovation

A plaque is given to recognize the submarine team from any design category that incorporates the most innovative design, construction and or performance attribute.

- First Place and Winner: Umptysquatch 8 – Sussex County Technical School in Sparta New Jersey, for their use of a Schauberger's Turbine Propulsion System, utilizing a 14-foot lathe as part of their manufacturing process and having a rear-facing pilot utilizing a forward look GoPro camera system for steering.
- Second Place: Knotty Dawg – University of Washington in Seattle, Washington, for using a two-school collaboration to construct their wooden hull; having dorsal and ventral fins with ballast to prevent torque roll and a central chassis chain geometry.
- Third Place: Rivershark Mod 1 – Rhein-Waal University of Applied Sciences in Kleve, Germany, for having a sonar-based autopilot system with artificial lateral line speedometer and a mirage drive outboard propulsion system.

Best spirit of the races

A plaque is given to the submarine team that displays the best gusto, fortitude and support for the other teams and overall best spirit. The winner is selected by the submarine teams themselves and is awarded in memory of the late ISR contestant, Steve Barton of team Sublime.

- Winner: OMER X – Ecole de Technologie Superiere (University of Quebec), in Quebec City, Quebec, Canada.

Smooth operator award

A plaque is given to a team in recognition of their efficiency in staging for the race course, racing the course, troubleshooting as necessary and otherwise preparing for their next run.

- Winner: Umptysquatch 8 – Sussex County Technical School in Sparta New Jersey

Best design outline

A plaque is given to the team that submits the best design outline report on their submarine.

- Winner: Godiva 3 – University of Warwick in Coventry, England

Best use of composites

A plaque is given to a team in recognition of the boat that makes the best use of composites.

- Winner: Godiva 3 – University of Warwick in Coventry, England, for their use of recycled carbon fiber.

Speed awards

The categories for speed awards includes combinations of the following characteristics: one-or two-person boats, propeller or non-propeller boats and independent, high school and college-level teams.

- Winner: SUBLIME – Hernando County Schools in Brooksville, Florida, with a speed of 5.77 knots.

Speed awards by category

One person / propeller / college

- 1st place – Florida Atlantic University – HPS Atlantic – 4.90 knots
- 2nd place – Polytechnique Montreal – Archimede VII – 4.05 knots
- 3rd place – University of Warwick – Godiva 3 – 2.52 knots

One person / propeller / high school

- 1st place – Hernando County Schools – SUBLIME – 5.77 knots
- 2nd place – Old Saybrook High School – Jesse V – 3.27 knots
- 3rd place – A.C. Mosley High School – Trigonus – 1.28 knots

One person / propeller / independent

- 1st place – Kids Into Discovering Science – Rubber Ducky – 1.24 knots

Two person / propeller / college

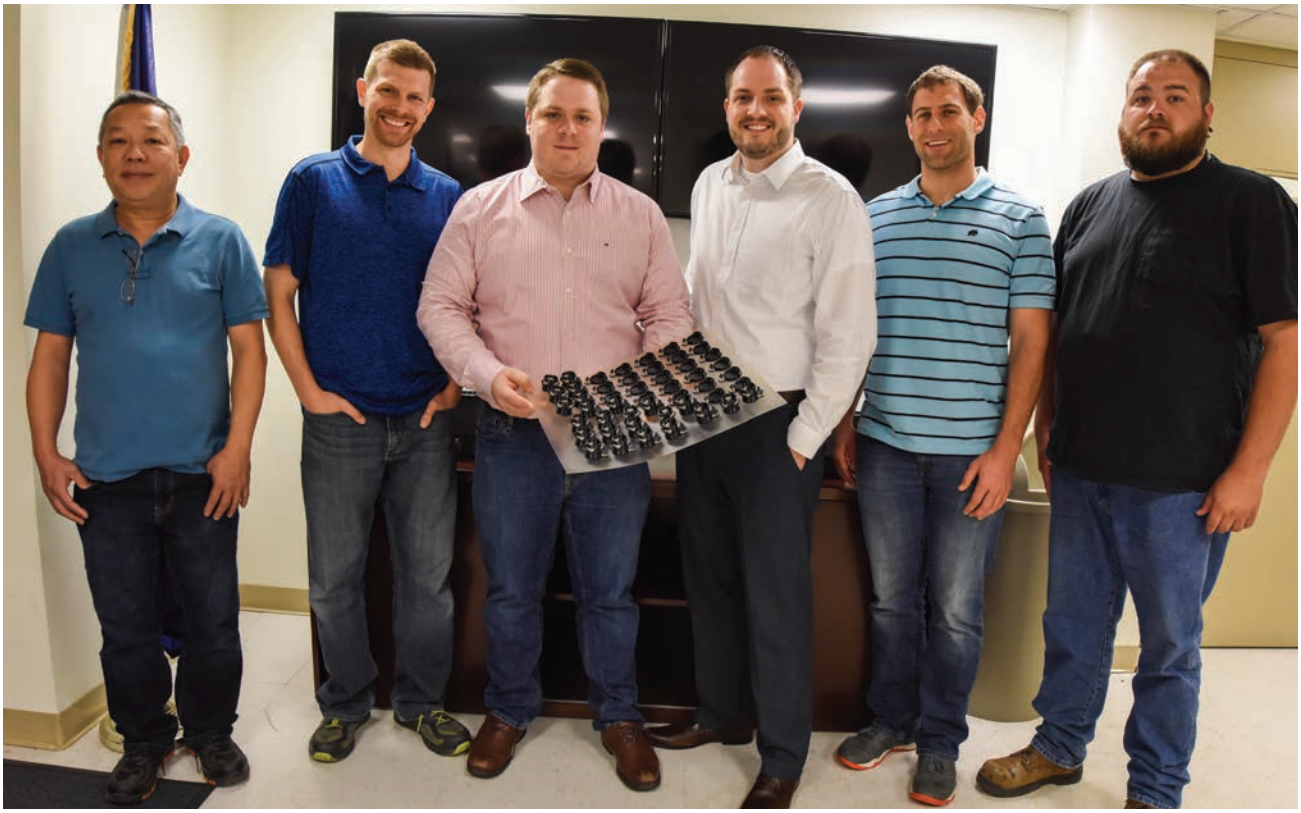
- 1st place – University of Washington – Knotty Dawg – 3.27 knots
- 2nd place – University of Veracruz – Tijuana Taxi – 1.03 knots

One person / non-propeller / college

- 1st place – Ecole De Technologie Superieure – OMER X – 4.59 knots
- 2nd place – Delft University of Technology – WASUB VII – 2.09 knots
- 3rd place – Rhein-Waal University of Applied Sciences – Rivershark Mod 1 – 1.49 knots

Warfare Center working group quickly meets NAVAIR requirement with 3-D printers

By Dustin Q. Diaz, Carderock Division Public Affairs



Naval Surface Warfare Center (NSWC), Carderock Division employees (from left) Dung Su, Frank Neukam, Sam Pratt, Jonathan Hopkins, Keith Brennan and Ryan Franke display additively manufactured aviation parts they rapidly produced in a first-of-its-kind response to a critical fleet need in West Bethesda, Md., May 31, 2017. Carderock engineers collaborated with other commands from the Additive Manufacturing Warfare Center Working Group, including NSWC Indian Head and NSWC Dahlgren and Combat Directions Systems Activity Dam Neck, to fulfill a request from Naval Air Systems Command for parts to restore stalled training operations for the T-45 Goshawk. (U.S. Navy photo by Dustin Q. Diaz/Released)

In a first-of-its-kind effort, the Additive Manufacturing (AM) Warfare Center Working Group (WCWG) recently combined their knowledge and resources to use 3-D printing to rapidly respond to a critical need from the fleet.

The group, comprising members of all of Naval Sea Systems Command's (NAVSEA) Warfare Centers, began working in late May to respond to a request from Naval Air Systems Command (NAVAIR) to restore stalled training operations for the T-45 Goshawk.

Liz McMichael, the AM integrated project team lead, said NAVAIR sought help when naval air crews flying the T-45 for the Aircrew Systems Program Office (PMA-202) began experiencing an increase in physiological episodes (PEs). A PE occurs when the aircrew experiences physical effects—from a lack of oxygen, contamination of air flow, or fluctuation in cabin air pressure—that impair their ability to safely fly their aircraft.

The Navy concluded a comprehensive review of the issue April 21. The review determined that PEs are a complex problem with possible interrelated causes, and the investigation into the root causes of the problem is ongoing.

McMichael said that while a longer-term solution is being sought, the short-term solution is a flip-top valve that will allow pilots to breathe cabin air at lower altitudes. She enlisted the assistance of the other members of the working group to help Naval Air Stations (NAS) Patuxent River and Webster Field quickly produce the valves in the needed numbers.

Sam Pratt, a mechanical engineer with Naval Surface Warfare Center (NSWC), Carderock Division's AM Project Office, said the first parts came off the printer

less than 48 hours after they got the call.

"It's a really cool example of what you can do with additive manufacturing on short notice in the real world," Pratt said. "In this case, we've got this need: a critical system is down; we need to figure out how we can fix it and get these pilots back in the air. We needed a lot of parts on really short notice.

"With AM, you don't need any tooling, you just need the design and, in this case, we have that, so there's no need to spend millions of dollars over many months to create an injection molding shop and deal with all the logistics there. In the span of about a week and a half, we've gone from design to approval to manufacturing and, then, installation."

McMichael said meeting the short timeline to print the valves, which were designed to be printed on industrial polymer 3-D printers, would have been impossible without using resources across NAVAIR and NAVSEA.

Jonathan Hopkins, deputy branch head for NSWC Carderock Division's Additive Manufacturing Project Office, said the Carderock personnel engaged the rest of the working group to establish a distributed manufacturing base, which included printing at the nearby NSWC Indian Head Explosive Ordnance Disposal Division and NSWC Dahlgren Division and Combat Direction Systems Activity Dam Neck to provide parts by the June 2 deadline. NAVAIR provided funding to NSWC Carderock Division May 26, which moved forward with a unified AM presence among the command's codes and partner printers, producing 48 of the needed valves over Memorial Day weekend and more than 300 altogether.

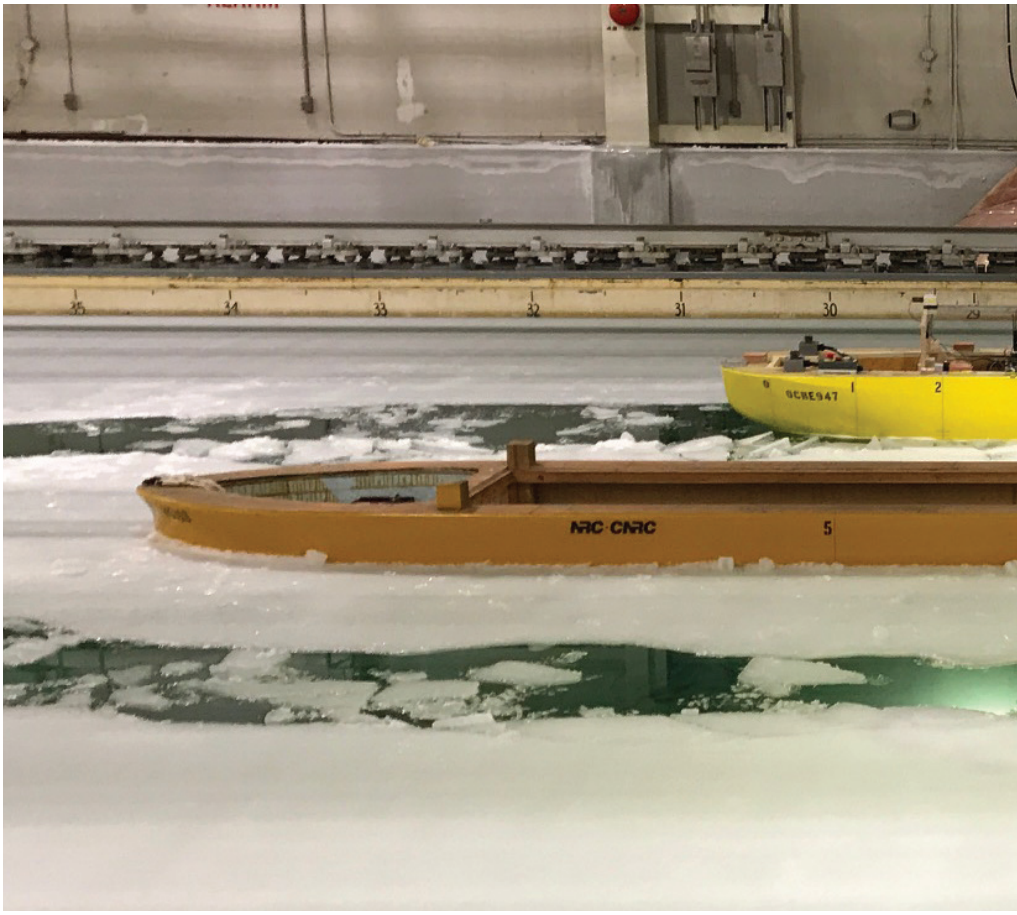
Frank Neukam, supervisor of NSWC Carderock Division's Engineering Support Group, said collaborating within Carderock and the AM working group to quickly meet this need was an awesome experience for him, one he found particularly meaningful as the work produced a tangible benefit to the fleet and its war fighters.

"This is exactly what this type of technology should be used for," Neukam said. "I think it came out really well, and it gives us hope for the future, absolutely."

Additively manufactured aviation parts rapidly produced in a first-of-its-kind response to a critical fleet need by employees at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., May 31, 2017 (U.S. Navy photo by Dustin Q. Diaz/Released)

Carderock joins international team to test new icebreaker designs

By Dustin Q. Diaz,
Carderock Division Public Affairs



Engineers and scientists from Naval Surface Warfare Center, Carderock Division are working with an international, multiagency team to define requirements for and create the U.S. Coast Guard's (USCG) next heavy polar icebreaker. On July 26, Carderock employees joined representatives from the Coast Guard, U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T), Naval Sea Systems Command (NAVSEA), and the National Research Council of Canada (NRC) at NRC's St. John's, Newfoundland, ice-test facility to discuss and showcase progress made on the testing and evaluation of design models for the icebreaker acquisition program.

"This collaboration benefits both countries as they engage in vital research and development to improve the technology of icebreaking ships," said NRC President Iain Stewart at the event. "Our knowledge of how ships and offshore structures can operate in harsh environmental conditions combined with our world-class research facilities and expertise positions Canada as a strategic partner in providing safety and efficiency to the new U.S. polar icebreakers."

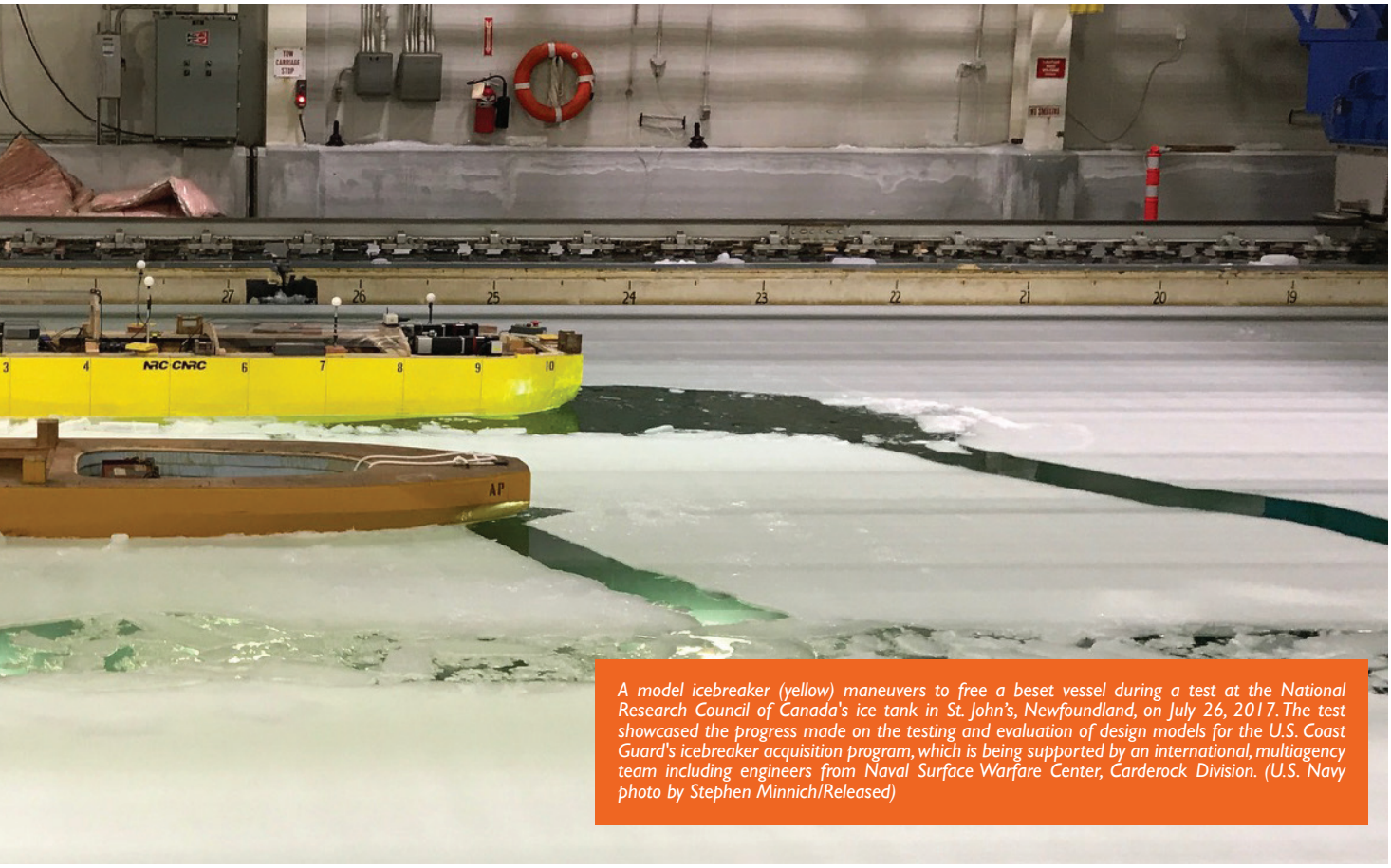
This testing is the result of a partnership between these parties established in February, which was developed under the agreement between the U.S. and Canada for Cooperation in Science and Technology for Critical Infrastructure and Border Security enacted in 2004. It includes analyses of maneuverability in ice and icebreaking resistance and powering, and will be used to further inform the baseline requirements for new heavy polar icebreakers, expand current icebreaker design and operational knowledge, and support the urgent need to recapitalize U.S. heavy icebreaking capability.

"Model testing activities enable us to examine critical design elements and make informed design decisions early in the acquisition process," USCG Rear Adm. Michael Haycock, assistant commandant for acquisition and chief acquisition officer, said during remarks at the event. "The data we gather from model testing at the NRC is going to be a major driver of our heavy polar icebreaker acquisition program's success and will be critical to our efforts to effectively manage costs, mitigate risks, and maintain an accelerated program schedule."

NRC's facilities in St. John's, Newfoundland, are home to one of the world's largest ice-tank facilities, which is used to measure the performance and evaluate the safety of ice-going ships and structures in controlled model-scale conditions. This ice tank, which at 270 yards is the second-longest in the world, is capable of modeling a wide range of marine ice conditions, including first-year and multiyear ice, pack ice, ridged ice and glacial ice.

The Coast Guard currently has two polar icebreakers – the heavy icebreaker USCGC Polar Star (WAGB 10) and medium icebreaker USCGC Healy (WAGB 20) – and both have been in service fulfilling regular commitments for decades under very arduous conditions, according to Neil Meister, technical director of the polar icebreaker replacement project within the Coast Guard.

"You don't build a heavy icebreaker except once in a generation," Meister said. "These are considered national strategic assets. What we're making is essentially a steel fist that has to last for decades and be able to float, run into



A model icebreaker (yellow) maneuvers to free a beset vessel during a test at the National Research Council of Canada's ice tank in St. John's, Newfoundland, on July 26, 2017. The test showcased the progress made on the testing and evaluation of design models for the U.S. Coast Guard's icebreaker acquisition program, which is being supported by an international, multiagency team including engineers from Naval Surface Warfare Center, Carderock Division. (U.S. Navy photo by Stephen Minnich/Released)

things, and operate at 40 below zero. These ships do a lot of crazy things that most ships don't do. The capabilities we are building into the replacement reflect that."

The Navy and Carderock are in a position to support the Coast Guard in terms of the research and development efforts that are associated with acquiring a platform with icebreaking capability, according to Stephen Minnich, a naval architect at Carderock. Scientists and engineers at Carderock and other Warfare Centers are contributing to the Coast Guard and Navy integrated program office (IPO) acquiring the icebreakers through requirements development, engineering support, and research and development activities. Engineers from Carderock have also participated in the ice testing at NRC.

NRC has widely validated expertise in recreating the material properties of sea ice at model scale, which is crucial to the evaluation of vessel and structure performance in ice conditions, and Minnich said this testing has demonstrated the value that a unique facility such as NRC can offer to support the icebreaker acquisition program.

"Modeling capabilities such as the breakout of a beset vessel is a complex phenomenon that is challenging to predict numerically," Minnich said. "The powering requirement for the icebreaking mission is an important design and cost driver that ice testing helps to predict. In addition to helping the IPO understand the design trade space, access to this type of facility and expertise through this collaboration is an incredible learning opportunity for our scientists and engineers."

DHS Under Secretary (Acting) for S&T William N. Bryan agreed, calling the tests a wonderful example of international and cross-component collaboration.

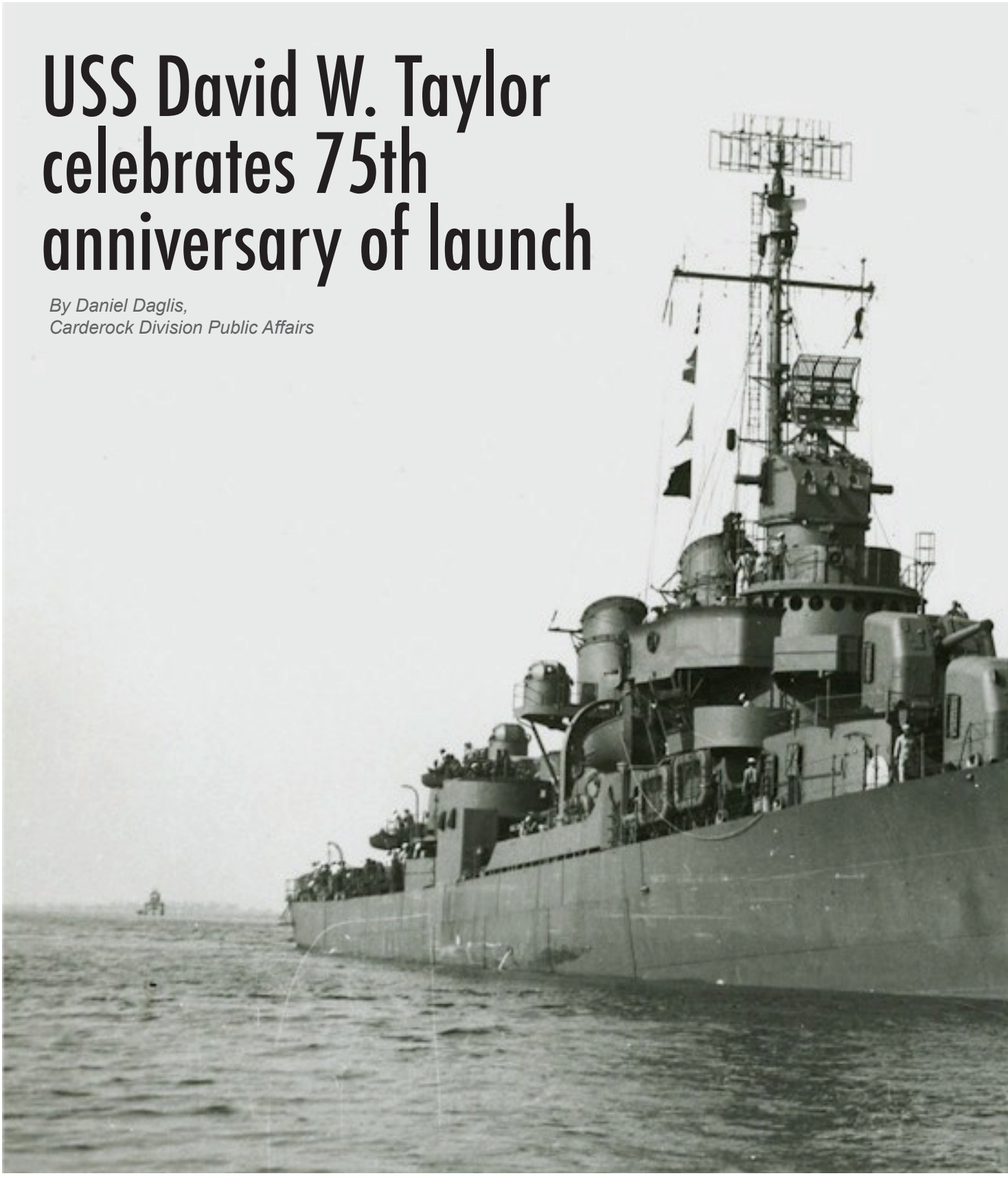
"Supporting the operational mission of DHS is why S&T exists," Bryan said during the event. "In this case, I am particularly proud that S&T is able to work with our neighbors to the north and bring their expertise to bear on supporting the mission of the Coast Guard."

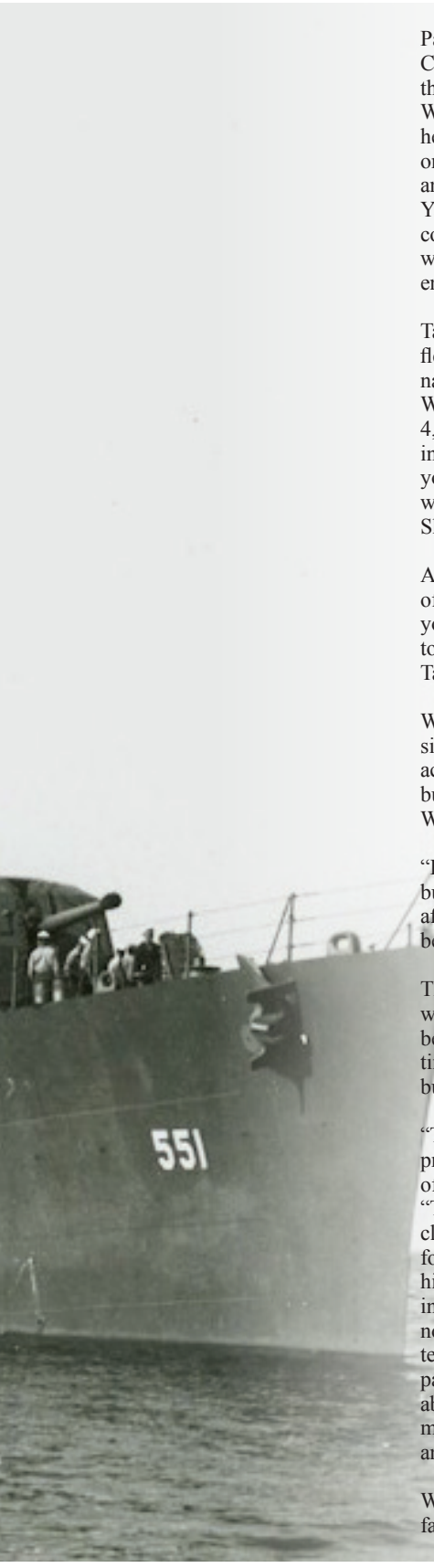
This round of ice-testing activities formally began in April and concluded in August. Now, the Coast Guard and Navy are conducting complementary model testing to evaluate the performance in open water at Carderock's West Bethesda, Maryland, headquarters. The heavy polar icebreakers will spend considerable time transiting in ice-free conditions, emphasizing the importance of the open-water performance. Model tests at Carderock will evaluate seakeeping, resistance, powering and maneuvering performance with the ultimate goal of balancing icebreaking and open-water mobility capabilities.

"NRC set the bar high supporting the IPO with the ice testing and our test teams will strive to maintain that level of support as we execute the planned test campaign at Carderock," Minnich said.

USS David W. Taylor celebrates 75th anniversary of launch

By Daniel Daglis,
Carderock Division Public Affairs





Part of the Naval Surface Warfare Center, Carderock Division mission is "maintaining the David Taylor standard." The historic David W. Taylor Model Basin located at Carderock's headquarters in West Bethesda, Maryland, is one of the largest model basins in the world and was built to replace the Washington Navy Yard's Experimental Model Basin, designed and constructed by Rear Adm. David W. Taylor, a world-renowned expert in naval architecture and engineering.

Taylor's contributions to the U.S. Navy and the fleet are so vast the Navy honored him with the naming of a Fletcher-class destroyer, USS David W. Taylor (DD 551). The ship was launched July 4, 1942, by the Gulf Shipbuilding Company in Chickasaw, Alabama, and christened by his youngest daughter, Imogen Taylor-Powell, who worked as a secretary for the Navy's Bureau of Ships at the time.

According to historian and Carderock's Curator of Ship Models Dana Wegner, Imogen was the youngest of four children and was one of three to be born at the Washington Navy Yard, where Taylor and his family resided in Quarters R.

Wegner also pointed out that there was great significance in the place in which the ship was actually launched. Gulf Shipbuilding had been built by subsidies offered by Taylor during World War I.

"It may have just been an interesting coincidence, but here Imogen was launching the ship named after her father in a yard that actually owes its beginnings to her father," Wegner said.

The ship was commissioned Sept. 18, 1943, which Wegner said is fairly quick for a ship between launch and commissioning, but at that time was one of many Fletcher-class ships to be built for use during World War II.

"The Fletcher-class is probably one of the most prevalent ones in World War II. They built 175 of them, pretty much all the same," Wegner said. "They began formulating plans for the Fletcher-class in 1939, which meant that there were plans for the ship about a year before Adm. Taylor himself died. All of the new U.S. destroyers in WWII built specifically for the war were notable because they used high-pressure, high-temperature steam. So their engine rooms were particularly small, but the type of power they were able to produce and having a smaller engine room meant you could carry more weapons and Sailors and everything else to fight more efficiently."

Wegner noted that despite being commissioned fairly late in the war – and with the U.S. already headed toward victory – USS David Taylor did great work and would go on to have a remarkably long career.

"When they started building the ship, things were pretty dark. Nobody knew how the war was going to end up. After the attack on Pearl Harbor the Navy lost half its fleet, then there were a series of battles that we lost. At the Battle of Midway is when things started to turn around.

"By the time the Taylor actually saw service, things were looking up, but they were island-hopping and preparing for the invasion in Japan. So all those battles in the Pacific, those were significant battles; the ship did significant things throughout its entire career with the U.S. Navy. It struck a mine or other explosive at one time, and the fact that the ship wasn't lost is a tribute to how well-designed it was. Taylor himself had actually pioneered the early efforts on designing ships to be mine-proof and explosion-proof. He and one of his fellow Naval Academy graduates that worked with him were the founders of the initiative on how to build the unsinkable ship, which is something departments continue to work on at Carderock today."

According to the Naval History and Heritage Command (NHHC), USS David W. Taylor received eight battle stars for World War II service. Notably, from June 15 to Aug. 4, 1944, the vessel sailed in the screen of escort carriers and fleet oilers supporting the Marianas operation. On July 4, 1944, it aided USS Riddle (DE 185) in attacking and sinking the Japanese submarine I-10.

Sailing from San Diego on May 15, 1945, the ship bombarded Emidj Island on June 18 on its way to Okinawa, arriving June 20. The ship then operated with a task group off Okinawa and arrived at Takasu, Kyushu, on Sept. 4 as an escort for a convoy carrying occupation troops. It covered the landings at Wakanoura Wan and Nagoya before sailing Oct. 31 for San Diego and arriving Nov. 17. David W. Taylor was placed out of commission in reserve there Aug. 17, 1946, after the war.

Information provided by NHHC states that on May 15, 1951, the destroyer was leased to Spain where it served as Spanish destroyer Almirante Ferrandiz for the next 20 years. Spain purchased the destroyer Oct. 1, 1972, and it remained in service until being disposed of sometime in 1988.

"I think it's time we have another ship named the David W. Taylor," Wegner said.

High-velocity learning continues at Carderock

By Dustin Q. Diaz, Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division is embracing Navy leadership's vision of strengthening its people through culture change with high-velocity learning (HVL) as the tool to identify and implement this change.

Dr. Tom Marino, an engineer with the Corporate Business Office and Carderock's HVL lead, has been holding regular brown-bag meetings to educate the workforce on what HVL means, how to use it and what it can help them achieve. He held the third of these brown bags at Carderock's West Bethesda, Maryland, headquarters Aug. 9.

"HVL really comes from Chief of Naval Operations Adm. John Richardson; it's an initiative he puts forth in his Design for Maintaining Maritime Superiority," Marino said to start the brief. "He has four primary objectives: strengthening our naval power, strengthening our people, strengthening our teams and strengthening our network of partners. HVL is really about strengthening our people through culture change. We do that by leveraging knowledge."

Marino went over HVL basics for first-time attendees and spoke about the four S's of HVL: see, swarm, share, sustain. He said the "see" part is about detecting problems as they occur, identifying normalized deviation–workarounds used in daily work that can lead to long-term problems–and reporting those problems, as well as the solutions.

"HVL is not a template for solving problems, but for how we report them, and that plays in with sharing, as well," Marino said. "Normalized deviation can kick the can of a problem down the road to someone else separated by time and distance."

Marino also talked about swarming, saying it's about applying resources quickly to all available shareholders to prevent bias from entering a process. He then introduced the brown bag's first speaker and Carderock's director for unmanned vehicles and autonomous systems, Reid McAllister. McAllister has been a Carderock employee for 32 years and is now seeing an idea he had back in 1991 come to fruition through HVL today.

"It had everything to do with collaboration and how all the Warfare Centers come together and focus," McAllister said. "I realized that Carderock Division does unmanned systems, so do the Dahlgren, Panama City, Newport, Keyport and the other divisions. They all have pockets of autonomy capability, but we're not doing it together. What we're doing is potentially a duplication of effort across the Warfare Centers.

"I wanted to put together a team that kind of addressed that and instead of us duplicating each other's efforts, we would bring the right expertise from each of the Warfare Centers and we would do this a lot cheaper, more effectively and collaboratively."

The Unmanned Vehicle and Autonomous Systems (UVAS) Warfare Center Working Group stood up September 2015 with representatives from all 10 Warfare Centers, all swarming the same problems. Since then, the UVAS Group has held weekly phone conferences and periodic off-site meetings incorporating younger engineers and seeing and swarming problems together.

"What we're trying to do is find out where we should actually be going relative to unmanned systems as an organization of all 10 Warfare Centers," McAllister said. "We'll use some tools to 'see' the problem. One is a SWOT analysis – strengths, weaknesses, opportunities and threats. Then we drop into that swarm mode where we start centering on concepts and ideas and how to move forward organizationally to solve problems. We are on the phone every week sharing our failures and successes, providing awareness on upcoming events.

"As far as 'sustain' goes, what we are trying to do is go after the culture. I've spoken to engineers at other Warfare Centers who said they weren't willing to work with Carderock before we started doing this. Through relationship building, negative perceptions are waning. I try to operate in total transparency and I'm happy to report that two years in, it is working and relationships are getting stronger. Operating transparently can be a pain and it has its costs, but it certainly has greater benefits than operating alone. I think it's better for the warfighter and that's the most important thing."

Jonathan Hopkins heads up a similar organization, Carderock's Additive Manufacturing Warfare Center (AMWC) Working Group. He said this group is looking at different ways to build quality, usable structures for the Department of the Navy that deliver on the promise of unmanned projects, like the Optionally Manned Technology Demonstrator, a 30-foot proof-of-concept hull that is modeled after today's SEAL Delivery Vehicle, but cannot yet operate in the water.

"We've helped grow this working group into an executive committee that brings in the Marine Corps and everyone across the naval enterprise to align our efforts and make sure everything is building toward enabling this technology as quickly and safely as possible within the fleet," said Hopkins, a mechanical engineer who also oversees Carderock's Additive Manufacturing Project Office. "My team is collaborating with industry and academia, as well as with Dr. Joe Teter, Carderock's technology transfer director, to develop cooperative research and development agreements with different companies. There are constantly announcements about new processes in additive manufacturing (AM) and we want to make sure we are making the right investments across the Navy, but that we are also abreast of the newest developments so when we are called on, we can make informed recommendations on how to move forward with the technology."

Hopkins said AM software is maturing to better understand the intricacies of the processes involved in 3-D printing and the working group is doing research to build on these advances. He called collaboration with partners like Oak Ridge National Laboratory and the other members of the working group key to Carderock and the Navy using this technology to its full potential. He also talked about Carderock's Manufacturing, Knowledge and Education (MAKE) Lab, a facility that inspires creativity and innovation by offering training to all employees in this enabling technology, including those unfamiliar with the 3-D process, and encouraging knowledge sharing among employees.

Hopkins and McAllister agreed that all federal employees and contractors can benefit from HVL, not just those at Carderock and NAVSEA. They hope to continue to sustain the knowledge sharing fostered by their working groups and believe these groups are a good model for others to emulate in building relationships through HVL.

High-velocity learning – the 4 S's

By Dr. Tom Marino, Corporate Operations Office

What are the 4S's and what do they mean? They are ways to decompose HVL interests or topic areas into work breakdown paths. Formally they mean see, swarm (solve), share, sustain. Some will point out we are already doing these things and on the surface there is nothing really new about them. One might argue this is just a repackaging of the same old concepts we've seen and heard before. However, there is a deeper meaning worth considering, and companies like Toyota and Alcoa have done remarkably well under this construct. Toyota doubled margins and increased output tenfold over their nearest competitor and Alcoa became the safest and most profitable natural resource producer in the world by applying these tenets. There are many other examples, and they all have one thing in common: aggressiveness about converting ignorance into knowledge – helping people see when things are not working; helping an organization, a team or an individual acknowledge a gap or shortfall.

See is really about enabling decision making at the smallest unit possible. It's about avoiding normalized deviation. In other words, it's about avoiding Band-Aids or workarounds that temporarily solve problems but usually shift the burden elsewhere in the process (this is a systems thinking/business dynamics archetype). Seeing may sound like a simple task, but I like to use Plato's "Allegory of the Cave" as a powerful reminder of how people inherently resist change even if it's in their own best interest to consider alternatives. Another analogy I like to use is the image of two cavemen pushing a cart with square wheels up a hill but who are too busy to notice the caveman with the round wheel idea. A typical bureaucracy struggles to "see" not because it resists, but because it is very well adapted to maintaining the status quo, and maladapted to rapid changes. The "boiling frog" parable is an appropriate analogy.

Swarm - Capt. William Greene (formerly of NAVSEA 04) shared with the Navy's HVL Community of Practice (CoP) what I consider one of the best definitions of "swarm." Specifically, swarm refers to addressing any deviation immediately with all stakeholders. The rapid response is important to maintain the integrity of "eye witnesses" and reduce bias and variability which grow with time and distance from the original event. Stakeholder is defined as broadly as possible (i.e., think R. Edward Freeman's "Stakeholder Theory of the Modern Corporation"). Think of stakeholders as an open public forum. Think "Team of Teams" by retired Gen. Stanley McChrystal. Toyota, Alcoa and others created highly adaptable workflow and processes by constraining procedures to the maximum extent possible. At first this might seem like a paradox, because constraint seems like the antithesis of adaptable. However, the constraint is really focused on eliminating deviation and avoiding its normalization. Think of a curve fit with error bars around the data points to capture uncertainty. The adaptability is in reducing the magnitude of the error bars while maintaining the integrity and constraint of the curve.

Share is really about leverage. How can other organizational units or individuals benefit from existing knowledge? Knowledge is not kept locally. Our focus at Carderock started with a few critical shifts in behavior and sharing outside the division. Y12 is a great example and Carderock has been acknowledged by the HVL CoP for leading this. Steven Spear likes to say leverage is about understanding the collective experience, what has been, what the future holds. At Carderock this is an important part of the command's strategy, specifically modern knowledge transfer.

Sustain is is really about cultural stickiness, maintaining knowledge and awareness through workforce and organizational transitions (retirements, reorganizations) or in circumstances where activities are not frequent in natures (a great example being how to safely and effectively conduct full-scale, live-fire shock trials – tests typically only conducted with first-of-class ship deliveries). We honor the strengths within our existing culture and try to push down decision-making to the smallest unit level possible. We integrate formal and informal interventions and empower a coalition of change agents. For sustaining cultural stickiness we are leveraging the persistence of knowledge management tools such as fusion and wiki.

In general, try to remember that HVL is not formulaic and so the 4S's are not a templatic solution for HVL. HVL is more cultural and less about structure. The 4S's are a representation or framing of the performance output (how did we leverage or enhance cultural stickiness?). True HVL organizations will say they can't tell you how they're succeeding, but they can show you. I like to use the story of the ship with the broken engine and no one could figure out what was wrong. So they call an old retired engineer who shows up with his old worn tool bag. He looks around and finally pulls out a hammer and gently taps. The engine starts. The $10,000 bill seems high for a simple procedure and the company asks for an itemized list of services. So the old man hands them an invoice listing $2 for tapping the engine and $9,998 for knowing where to tap.

Dr. Eric V. Thompson, vice president and director of Strategic Studies Center for Naval Analysis suggests we stop thinking about it as high velocity and stop thinking about it as learning. It's really about generating an increase in performance over a shorter amount of time, so it's about performance throughput. It's about competitive advantage through cost advantage, specifically through economies of learning. Repetition and shared knowledge develops both individual skills and organizational routines. The more complex a process or product, the greater potential for learning. A common example points to the production of the B-24 Liberator. In 1943 it took 40,000 labor hours to build a single bomber. By 1945 it took only 8,000 labor hours. Dr. Thompson also cautions the use of traditional education and training environments. We are changing the deep seeded culture, i.e., where training grows its people through restricted pipelines, because learning in these restricted pipelines does not bend the performance curve. It's about creating real stickiness to cultural change and not about the impositions of organizational structures.

Carderock holds propulsor manufacturing industry day with industry partners

By Dustin Q. Diaz, Carderock Division Public Affairs

An undated photo of the future USS Washington (SSN 787) in Newport News, Va. The Navy accepted delivery of the 14th submarine of the Virginia class May 26, 2017. (U.S. Navy photo courtesy of Huntington Ingalls Industries by Matt Hildreth/Released)

The current fleet of Ohio-class nuclear-powered ballistic missile submarines represents a sacrosanct leg of the United States' nuclear triad, and by far its most survivable, according to Defense Secretary James Mattis. These submarines are being replaced by the Columbia class (CLB) of submarines, which will represent about 70 percent of the nation's strategic deterrence by 2042. Concurrently with designing and building submarines to replace the Ohio class, the U.S. Navy is constructing Virginia-class submarines (VCS) at about two per year. Together, the submarine fleet and associated Sailors comprise a critical component of the nation's security.

Naval Surface Warfare Center, Carderock Division's Advanced Propulsor Management Office (APMO) held an industry day in West Bethesda, Maryland, on Aug. 16, welcoming partners in private industry to discuss how to work together to meet Carderock's continuing mission of designing and manufacturing propulsors for new nuclear-powered submarines that carry the nation's weapons in its defense.

"I view propulsors as a crown jewel within Carderock Division. It's something that we have to do, that we will continue to do," said Larry Tarasek, Carderock's deputy technical director, at the start of the event. "I'm excited for this industry day. Today, you'll hear about technical needs, processes and much more. I'm excited to have our industry partners here, because we need your help to help Carderock and the Navy continue to do the critical work we need to do with propulsors."

Tarasek came to work at Carderock in the 1980s when President Ronald Reagan built up the Navy during the Cold War. From early in his career, Carderock Division's leadership ingrained in him the importance of propulsor design and he proceeded to work on propulsors for the VCS carrying out this mission today, as well as what would become the CLB submarine program. The propulsor, which is government-furnished equipment, represents a myriad of technical capabilities and has stringent manufacturing tolerances. It is a unique component, according to Matt Marburger, an engineer with APMO.

Design of the VCS propulsor, which keeps ships of that class steaming today, started at Carderock in 1992 with the first unit delivered in 2002. Eighteen propulsors have been delivered on schedule to date. The VCS program is currently planning for a force structure goal of 48 submarines altogether, though

Marburger said this may grow to 66 and possibly stress the defense industrial base. The Navy will also be simultaneously manufacturing the Columbia class in the coming decades. Carderock is currently exploring opportunities to improve margins on current VCS production schedules and needs help from industry partners to do that, according to Devin Stewart, APMO head at Carderock.

"We are responsible for developing the manufacturing strategy for building submarine propulsors and for overseeing the execution of that plan. Right now, we are developing a plan to do coordinated manufacturing of both Virginia and Columbia propulsors to support those programs, which is obviously a greater scope of manufacturing than we have been doing and is our challenge going forward here," Stewart said. "Our office is seeking to expand our industrial base in order to deliver high-quality propulsors to the Navy that meet or exceed our technical requirements, on time or ahead of schedule, at a reduced cost. What we're hoping to do today is get our potential industry partners the opportunity to see what submarine propulsors look like, how they're built, what the processes are and what steps are required to build them in order to give you some insight into how you can potentially participate."

Forty-four industry personnel representing 16 corporations were present for networking and discussion about the APMO's mission, generalized and technical requirements for the VCS and CLB programs and other topics, some of which were classified. As Carderock continues work on VCS and prepares for the fleet's transition to CLB, Matt Sermon, deputy program manager for the CLB program with Naval Sea Systems Command's Program Executive Office for Submarines which oversees the program, emphasized the importance of its success.

"We need to ensure that USS Columbia goes on patrol when it is scheduled to. Though that is years from now, it must happen. It must be there," Sermon said. "If it does not, we do not meet U.S. Strategic Command's requirements for the submarine force. We take it pretty seriously."

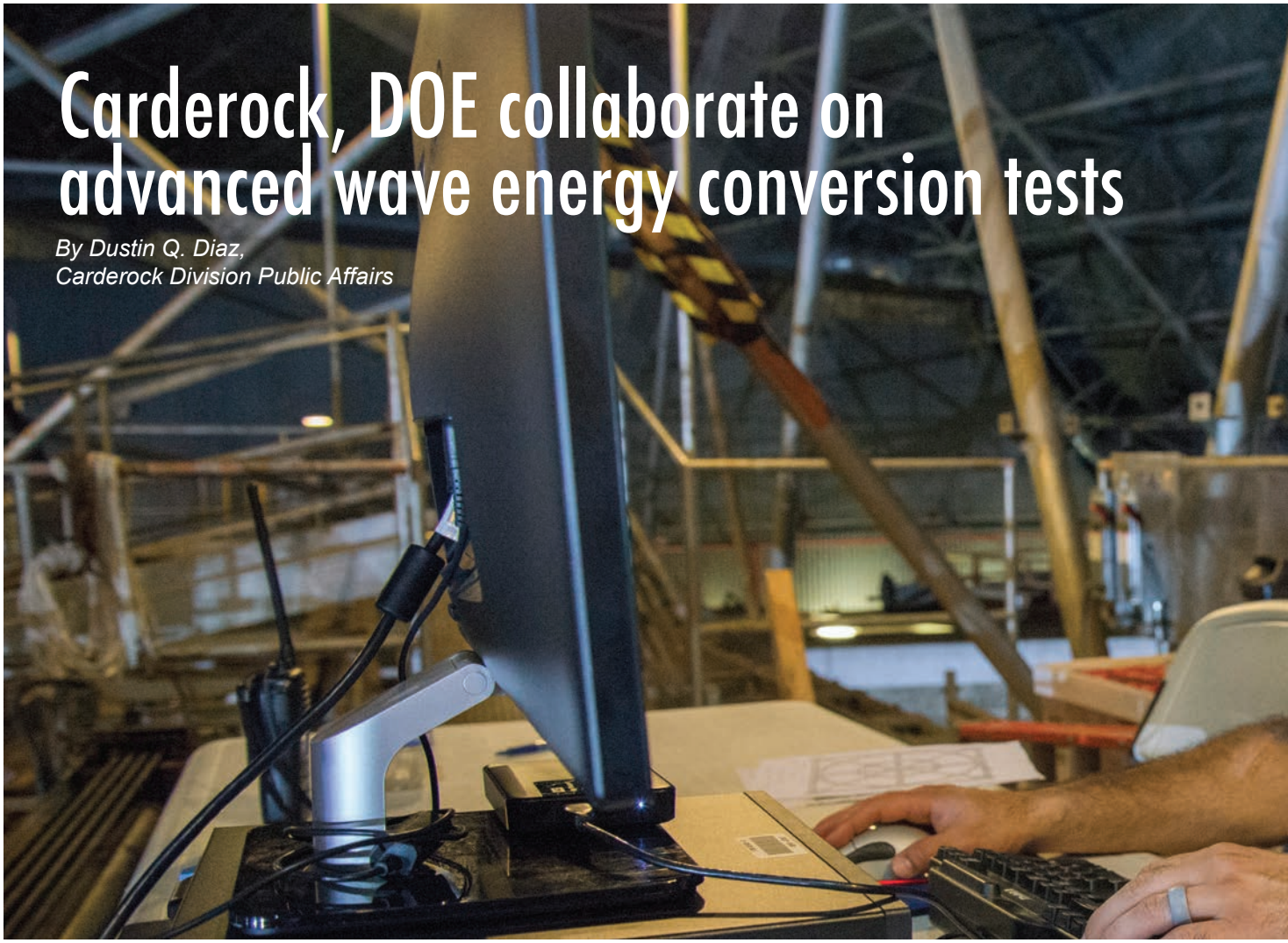
Frank Jurado, a contracting officer's representative at Carderock who helped organize the event, called the industry day a great success thanks to its face-to-face nature, which builds critical relationships in a way no other method can.

"You can't email a handshake, and industry day solves that," Jurado said. "Participants were exceptionally pleased with the collaborative event, having the opportunity to preview and discuss Navy technical requirements. This sets the tone for upcoming business forums that will dive into specific component design and manufacture activities."

The Virginia-class fast attack submarine USS Virginia (SSN 774) cruises through the Mediterranean while on a scheduled deployment within the U.S. 6th Fleet area of responsibility, Jan. 7, 2010. Virginia is home ported in Groton, Conn., and is the lead boat of the Virginia-class of submarines. (U.S. Navy photo by Mass Communication Specialist 2nd Class William Pittman/Released)

Carderock, DOE collaborate on advanced wave energy conversion tests

By Dustin Q. Diaz,
Carderock Division Public Affairs



Employees at Naval Surface Warfare Center, Carderock Division collaborated with partners from Sandia National Laboratories to test new control strategies for producing, converting and gathering wave energy in the command's Maneuvering and Seakeeping Basin (MASK) in West Bethesda, Maryland, July 24 through Aug. 4.

The combined engineering team members were testing a 1-ton wave energy converter (WEC) in the MASK with a focus on control to increase energy generation, according to Ryan Coe, a research engineer with Sandia's Albuquerque, New Mexico, facility.

"The whole purpose of this project and this test is to try to increase the amount of electrical energy that these wave energy converters generate and collect," Coe said. "We're looking at how to control the dynamics of the device and the device itself in a way to increase energy capture and increase the efficiency of the device."

Coe and colleagues from Sandia, a multi-mission laboratory contracted to support the U.S. Department of Energy's (DOE) National Nuclear Security Administration, previously worked with Miguel Quintero and other ocean engineers at Carderock to test a WEC in winter 2016 in the MASK, Carderock's indoor ocean and ship-model testing facility. In the year since, Coe said they've analyzed the data collected, designed new testing models and improved the hardware to implement advanced new controls.

"This device can move in three degrees of freedom: it can move in heave, surge and pitch; so it's basically all the motions in a single plane," Coe said. "It can move all over the place and we're able to collect energy in all those degrees of freedom.

"What that allows us to do is simulate a really wide range of different WECs and study those degrees of freedom separately and in conjunction with each other. We're now able to take the industry standard for WECs and apply a more complex, more optimal controller and as much as double the amount of power these devices produce in most sea states."

Quintero and Carderock colleagues like Dave Newborn have shared knowledge with DOE partners like Sandia and the National Renewable Energy Laboratory on large-scale wave energy conversion projects like this both during the previous test and during last year's Wave Energy

Prize contest, which was a public prize competition that involved nine different WEC tests in the MASK over just 10 weeks. A self-described "waves guy," Quintero said this knowledge share has been a great opportunity for all parties to learn and benefit from the collaboration.

"We've built a large, dedicated structure for these tests and mounted the WEC on it, which is different from the method we usually use," Quintero said. "We'll use controllers for rudders, props and wavemaking, but with the way they're implementing it, the methodology is a little different. It's beneficial for all of us to learn how to test a device like this in different situations. Sandia brings a lot of knowledge and expertise on how to do this, and we can share in it and have that knowledge to do similar tests in the future, even when they aren't here."

Giorgio Bacelli, another research engineer with Sandia, said he, Coe and Kevin Dullea, an engineer from Sandia's robotics department who built the new WEC, bring different techniques used in technologies like electronic systems, mobile phones and aerospace engineering to complement Carderock's background in ocean engineering and draw more energy from the converter. He compared these advanced power strategies to the process of swinging on a child's swing – putting energy in to gain more in return and managing that process.

"This is a substantially different problem than trying to control the route of a ship free-floating in the ocean's waves," Bacelli said. "We've developed a method of testing that runs in short periodic waves that repeat multiple times. This allows us to quickly sweep through the control system's parameters and see a response. So far, taking a different approach and bringing in tools that have been used for rockets, robots and radio tuners has been giving good results."

Coe said Sandia and DOE are looking at wave energy and other renewable energy sources to eventually power the continental U.S. electrical grid, and in the meantime, such development provides economic boosts in the form of new jobs required to install and develop technologies like WECs. But it also has applications that can directly benefit Navy and Marine Corps warfighters.

"The Navy and the Marines operate in the ocean and they need energy to do so, just like the U.S. power grid does," Coe said. "Further down the line, there's a possibility that a WEC might serve to power a naval off-shore base, an autonomous system or something else along those lines and provide greater operational capacity, similar to the flexibility a solar panel will give you today."

DOE officials including Alejandro Moreno, director for the Water Power Technologies Office in the Office of Energy Efficiency and Renewable Energy, visited the MASK Aug. 2 to see the test first-hand. This was the second of three rounds of testing Sandia planned to hold in the MASK, according to Coe, with the final and most technically advanced round set to take place later in the year.

Miguel Quintero, an ocean engineer assigned to Naval Surface Warfare Center, Carderock Division's Model and Testing Branch for Surface Ships, records and analyzes data collected from a wave energy converter being tested in the command's Maneuvering and Seakeeping Basin in West Bethesda, Md., Aug. 3, 2017. This WEC test was the second of its kind done as a knowledge share in collaboration with engineers from Sandia National Laboratory in the MASK as part of an effort to increase the efficiency and amount of power generated and collected by these devices. (U.S. Navy photo by Dustin Q. Diaz/Released)

UK graduate engineering training at Carderock

By Edvin Hernandez,
Carderock Division Public Affairs intern

Kishan Bhudia (left) and Chris Greenhough are British graduate engineers on a rotation at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md. (U.S. Navy photo by Edvin Hernandez/Released

The career progression of British graduate engineers working for the Ministry of Defence (MOD) can be supported by the Defence Engineering and Science Group (DESG) graduate scheme. In this program, British engineers rotate through a number of placements for a period of up to three years, acquiring valuable experience. For more than five years, Naval Surface Warfare Center, Carderock Division has welcomed and hosted DESG exchange employees at the West Bethesda, Maryland, headquarters.

"This is a really good starting point for that, really good experience," said Chris Greenhough, a British marine engineer. "The way that this graduate level placement is set up – it's OK to make mistakes here, whereas I'd rather be making mistakes now when you've got a bit of handholding. I can practice and get good at it."

While rotations are typically completed in the U.K., Carderock is one of three locations outside the U.K. where DESG graduates can complete one of their required placements. Over the course of their six-month-long placement, DESG

exchange employees, working under the Center for Innovation in Ship Design (CISD), have the opportunity to teach and lead a team of Naval Research Enterprise Internship Program (NREIP) undergraduate students to complete a ship design project.

"You wouldn't get a role like this where you're the leader of a few interns in the U.K., it's very difficult, it's a pretty unique opportunity," Greenhough said. "We do a whole ship design, so we take it from the start and go through all the stages of a ship design process," which is quite rare in the U.K.

Naval architect Kishan Bhudia is on his last placement at Carderock after completing two-and-a-half years of the DESG graduate scheme. He graduated from Cardiff University in Cardiff, Wales, U.K., in 2014 with a bachelor's degree in mechanical engineering. Between his undergraduate and graduate programs, Bhudia took a year off to begin working for the U.K. MOD. In that time, Bhudia worked with the Naval Authority Group in ship stability and structures. He also worked with the Queen Elizabeth Carriers (QEC), specifically with the Aircraft Carrier Alliance. In August 2016, he graduated with a master's degree in naval architecture from the University College of London.

"I decided to complete a placement here at Carderock because of the opportunity to manage and lead a group of interns. It is a fantastic opportunity for me to develop my leadership and communication skills, and targeting the necessary competencies to achieve professional engineering status," Bhudia said. "I also wanted to work on the future of ship designs and look at how the U.S. is designing the warships in comparison to the U.K."

Senior engineer within the Engineer and Scientist Exchange Programme (ESEP) and senior staff member for CISD Dr. Kieran Rutherford arrived at Carderock in 2016. He is mentor to both Bhudia and Greenhough while on their placement in the U.S.

"This is seen as one of the best placement opportunities due to the work and facilities available. I oversee and mentor design teams here. I am directly managing Kishan and Chris, so we work together to discuss their development objectives for the placements, review progress and report back to the U.K.," Rutherford said.

In 2004, Rutherford graduated from the University of Southampton, U.K., with a master's degree in mechanical engineering. He continued at Southampton to pursue a doctorate degree entitled 'Autonomous Underwater Vehicle Design Considering Energy Source and Hydrodynamics.' In 2009, Rutherford joined the Naval Systems Group with the Defence Science and Technology Laboratory (DSTL). With his love of concept design, technology and broad underwater experience, Rutherford has taken up a three-year exchange post in the United States, organized within the Platform Systems Division of DSTL.

> "One key aspect of the study guide is to have a project plan before the interns start; the interns are here for 10 weeks, and therefore it is important that they are working towards set objectives."

Bhudia and Greenhough arrived at Carderock in April, a month before the U.S. summer interns, to begin their study guides (project plans). This allowed both of them the chance to have a hand-over period with the previous British graduates, Greenhough said.

"One key aspect of the study guide is to have a project plan before the interns start; the interns are here for 10 weeks, and therefore it is important that they are working towards set objectives," Bhudia said. "I enjoy teaching others as you might forget something, for example, and then if you have to revisit that and teach it to someone else, that helps you in the long term because you will better understand the topic and subject."

Greenhough added that he is excited for the opportunity to lead a team. "I quite like the responsibility of being a mentor for someone, helping them guide through from the start to their finish … quite a warm fuzzy feeling when they get it right."

Both Bhudia and Greenhough are striving to become chartered engineers (CEng), which is a status of professional accreditation in the U.K. "In the U.S. this is called being a professional engineer (PE) as it is a licensed profession. Both CEng and PE mean that you have achieved a certain level of capability, are internationally recognized and have a legal responsibility for your work," Rutherford said.

Dr. Colen Kennell, who retired this summer as a senior naval architect at Carderock Division, was involved in assuring the program ran smoothly on the U.S. front. He took responsibility in helping exchange employees like Greenhough and Bhudia transition into the program.

"When we bring people in, in their first three years they are essentially in a development program and they rotate around to different offices and areas in the field here at Carderock," Kennell said. "After three years they (new government employees) are supposed to find a permanent home for a long-term job. Chris and Kish are in a comparable program in the U.K. and they are doing a rotation under the U.K. program. Involved in the sense that they are here for six months at a time at a rotation and typically Kieran is the official mentor, the U.K. supervisor of them. From my perspective, it has been quite fruitful for both parties."

Carderock's Combatant Craft Division, Old Dominion University collaborate on new unmanned vehicle

By Dr. Timothy Coats, Combatant Craft Division

Personnel from Naval Surface Warfare Center, Carderock Division Combatant Craft Division's (CCD) unmanned surface vehicle (USV) development group collaborated with faculty at Old Dominion University (ODU) in Norfolk to assemble a new USV at the university's Marine Support Facility on July 22.

Carderock's partnership with ODU led to engineers from CCD's Unmanned Maritime Mobility (UMM) group assisting Dr. Yiannis Papelis, a research professor at ODU's Virginia Modelling Analysis and Simulation Center (VMASC), in the assembly of a Wave Adaptive Modular Vessel (WAM-V).

The WAM-V was secured from Marine Advanced Research Inc., via Office of Naval Research Program Manager Kelly Cooper and is a very light and flexible catamaran designed to allow for a variety of applications, manned or unmanned, and attempts to mitigate wave-slamming effects on the payload bay with shock absorbers and hulls that conform to the surface of the water. It comes in a modular kit designed for easy and quick build and breakdown, and the team assembled it in less than one hour.

ODU is preparing to use the vehicle in next year's International Maritime RobotX Challenge, an international, multi-platform team competition held annually in Hawaii. The challenge is uniquely designed to include maritime, aerial and submersible tasks to broaden students' exposure to robotics applications and technologies. The near-term objective for this is that it would pull in students from the schools of marketing, finance, business and art for the purpose of supporting the event through accounting, web design, marketing ODU's accomplishments and getting local businesses to sponsor participation in the event. The long-term vision will see students and professors from the schools of engineering and engineering technology work to advance ODU's unmanned systems expertise and find additional opportunities to partner with the Navy's USV developments.

This assembly project was part of ODU's ongoing relationship with CCD on the UMM group's USV Navy Lab development, a collaborative environment for Navy laboratories and Warfare Centers and their partners in academia and industry to develop

Faculty and students from Old Dominion University (ODU) in Norfolk work with engineers from Naval Surface Warfare Center, Carderock Division's Combatant Craft Division to build an unmanned surface vehicle. From right to left, counter-clockwise: Dr. Yiannis Papelis, ODU; Nathan Sivertson, Carderock; Lawrence Michelon, Carderock; Chris Powell, ODU; Joseph Lemanski, ODU; and David Colburn, Carderock. (Photo provided by CCD/ Released

autonomous capability for sea surface craft. The Navy Lab is a two-part lab, which also can be described as somewhat of a digital twin, in which the Lab Afloat and Lab Ashore work together to develop, simulate and test developing technologies for autonomous navigation.

The Lab Afloat is a Carderock-owned USV repurposed from an 11-meter rigid-hull inflatable boat taken from Navy inventory and intended to be available for collaboration across Warfare Centers. It would facilitate the development of autonomous navigation (path planning and obstacle avoidance), craft automation, modularity and supporting interfaces. It would also support on-water testing and evaluation of sensors, improvements in situational awareness and safe pilotage methodology.

The Lab Ashore is intended to be a Carderock waterfront facility where collaborators further their developments in modeling and simulation, command and control, sensors, software verification and systems validation.

CCD has developed a craft automated control system (CACS) that can be standardized across different platforms and thus offers a standard interface for plug-and-play compatibility. The intent is to install CACS on USVs across the nation at various Warfare Centers and academic institutions to broaden the compatible Lab Afloat concept for wider collaboration on modeling and simulation, cybersecurity and anti-tamper, safe pilotage, payload testing, and autonomous navigation and perception. ODU's WAM-V will be one of those vessels that would be Lab Afloat compatible when it makes its expected maiden voyage in fiscal year 2018. CCD will also eventually install CACS on the Navy's other USVs.

Carderock is developing a cooperative research and development agreement that would allow CCD and ODU access to one another's facilities and personnel to expand this partnership. Furthermore, supervisory control, perception and autonomous navigation developments on the WAM-V will be tested on the Lab Afloat and potentially transfer to the Navy. Others within the Naval Research and Development Enterprise, along with partners from academia and industry, are welcome to participate.

For more information on CCD at http://www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Carderock/Who-We-Are/Norfolk-Virginia/.

For more information on the WAM-V, visit http://www.wam-v.com/.

NAVSEA recognizes Carderock innovators, partners for unprecedented naval asset

By Dustin Q. Diaz, Carderock Division Public Affairs

Naval Sea Systems (NAVSEA) Commander Vice Adm. Tom Moore, left, and NAVSEA Executive Director Jim H. Smerchansky, far right, present members of Naval Surface Warfare Center, Carderock Division's Disruptive Technologies Laboratory and their partners with a 2017 NAVSEA Commander's Award for Innovation in the Humphreys Building at the Washington Navy Yard July 19, 2017. This team created the largest 3-D printed naval asset ever, a proof-of-concept hull print for the Optionally Manned Technology Demonstrator. (U.S. Navy Photo by Juan P. Liriano/Released)

Members of Naval Surface Warfare Center, Carderock Division's Disruptive Technologies Laboratory (DTL) and their partners were awarded a 2017 Naval Sea Systems Command (NAVSEA) Commander's Award for Innovation July 19 for their work with partners and sponsors in achieving an unprecedented feat through additive manufacturing (AM).

With sponsorship from the Office of Naval Research (ONR), the DTL worked closely with military and government partners to rapidly design and print prototypes using a large-scale AM platform located at Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. This team created the largest 3-D printed naval asset ever, a proof-of-concept hull print for the Optionally Manned Technology Demonstrator (OMTD). According to sponsor Michael Wardlaw, head of maritime sensing at ONR, the OMTD team assembled a large and diverse coalition to demonstrate the scalability of AM to various full-scale naval missions.

"The DTL at Carderock, and DTL Director Garry Shields in particular, has been incredibly successful in creating, cultivating and leveraging an extensive coalition of willing participants in a regular drumbeat of technology discovery discussions. These discussions have consistently yielded new and innovative approaches for addressing some of the Navy's most significant operational constraints," said Wardlaw, who provided technical guidance, programmatic support and principal funding behind OMTD. "Our intent was to provide something so disruptive to conventional expectations that it would demand reflection and re-evaluation of our commonly held constraints about how tactically relevant platforms can be built."

The OMTD test article is 30 feet long and based on the Mark 8 Mod 1 swimmer delivery vehicle (SDV) currently in use, which is a manned submersible used to deliver swimmers and their equipment for special operations. Each SDV hull takes between three and five months to manufacture at a cost of $600,000 to $800,000 each, while rapid prototypes can be additively manufactured at a

Rachel Meyerhofer and Jeffrey Banghart, (left) student interns temporarily assigned to Naval Surface Warfare Center, Carderock Division's Disruptive Technologies Laboratory (DTL) under the Naval Research Enterprise Internship Program (NREIP), work with Lt. Brian Hart (seated) under the supervision of DTL deputy director and NREIP mentor Harry Whittaker (standing) to stream video from one Microsoft Hololens augmented reality heads-up display to another as part of a project they are working on for the next version of the Optionally Manned Technology Demonstrator in West Bethesda, Md., July 21. (U.S. Navy photo by Dustin Q. Diaz/Released)

fraction of the cost and in days or weeks, according to Shields, who is the OMTD Leadership Team leader.

"We asked ourselves, 'Can we do it a different way and get different results?'" Shields said. "This is a collapsing of the design and manufacturing spiral at an incredible iteration rate at very low cost. The impact of this may be that we change the way we play the game."

The current test article exists thanks to a phone call Shields placed to Dr. Lonnie Love, Manufacturing Systems Research Group leader at ORNL's Manufacturing Demonstration Facility (MDF), part of the Department of Energy (DOE).

"Last year, Garry called me and pitched the idea of using large-scale AM for naval applications and it was like two sparks hitting at the same time," Love said. "The MDF had all the tools and capabilities to address his challenges. It was great being able to reach outside the box and come up with a collaborative solution engaging both DOE and DOD. We're putting puzzle pieces together and advancing on both sides."

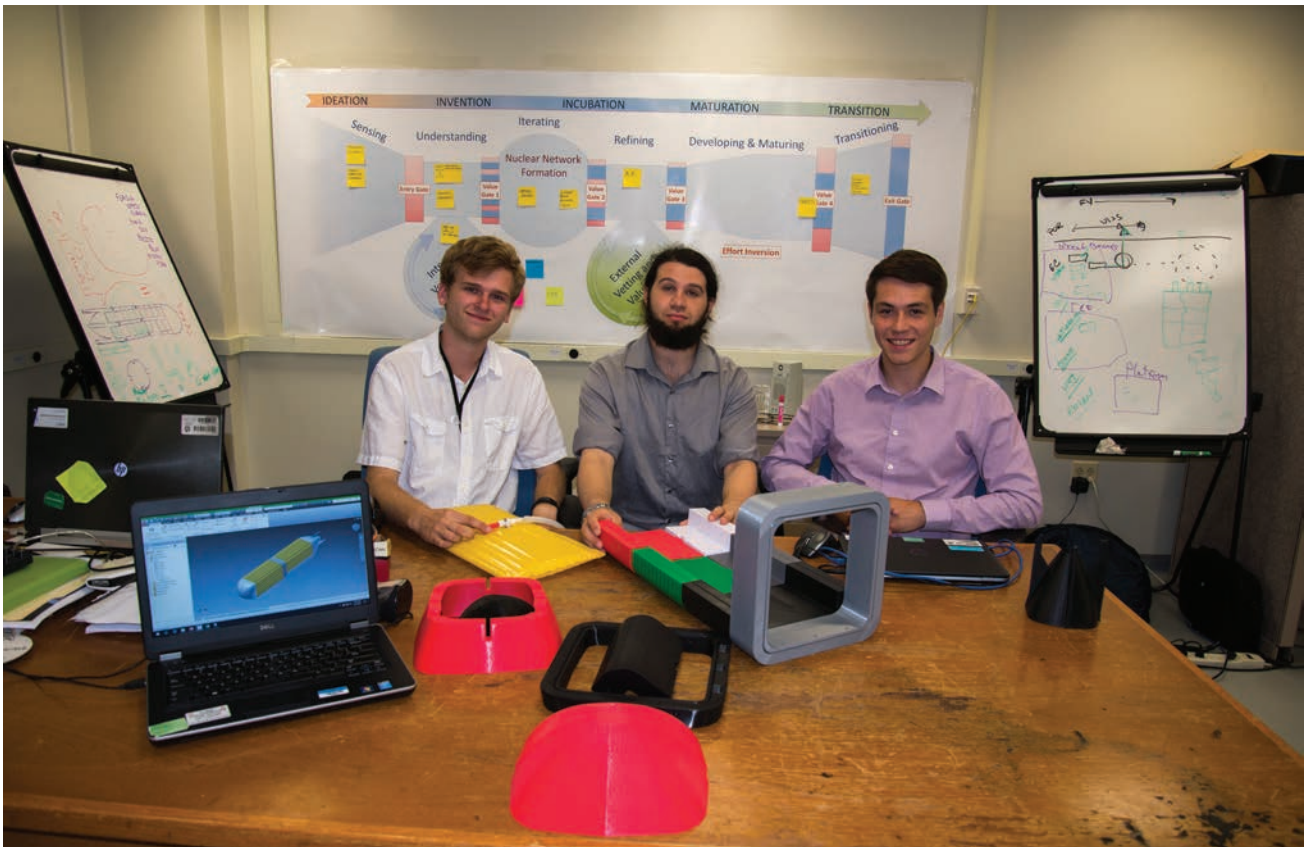
Partners at the two-week rapid prototyping event in August 2016 included U.S. Army Picatinny Arsenal; Navy Special Warfare; ONR; Defense Advanced Research Projects Agency; Naval Air Systems Command; the Johns Hopkins University Applied Physics Laboratory; NSWC Crane Division; NSWC Panama City Division; NSWC Philadelphia Division; Naval Undersea Warfare Center Newport; and Portsmouth Naval Shipyard.

Kevin Shay and Derek Morin, engineers with the Y-12 National Security Complex, also participated in this event, providing input on materials and machines for AM and producing a small-scale prototype overnight on the first day for further discussions by the team.

"The activity reinforced for me how an exciting technology like AM gets people fired up and thinking in ways they haven't thought before," Shay said. "Because of the compartmented nature of our mission, I sometimes feel like I work in a bubble. This activity revealed to me that we have really talented people contributing to our country's security."

The OMTD group then split into three teams that each created scaled prototypes using ORNL's AM systems and the SDV as a template during the first week. These prototypes progressed from one-twenty-fourth scale to one-twelfth and then one-third, with the team looking at the pros and cons of each design and collaborating to reach a consensus on a single design.

"In the course of one week we iterated through several design exercises that helped us optimize our design for AM and make decisions on production components," said Chris Van Valkenburgh, innovation manager of



College students (from left) Joshua Simmons, Ryan Assi and Quincy Lowman) temporarily assigned to Naval Surface Warfare Center, Carderock Division's Disruptive Technologies Laboratory (DTL) under the Naval Research Enterprise Internship Program (NREIP) exhibit parts of the expandable inflatable submersible project they are working on as a team project for the next version of the Optionally Manned Technology Demonstrator in West Bethesda, Md., July 21. (U.S. Navy photo by Dustin Q. Diaz/Released)

the Innovation Project at Portsmouth Naval Shipyard. "No one person can do everything; it requires teamwork and trust to develop a printable design. This established a marketplace of ideas and when we sat down together as a group to agree upon a common design, we were able to pick and choose components and features from competing designs."

Simeon Ryan, a naval architect with Carderock's Center for Innovation in Ship Design at Carderock's headquarters in West Bethesda, Maryland, created the initial 3-D model of the OMTD design using 3-D modeling software, worked with colleagues on the OMTD's energy module and made multiple trips to ORNL with Shields. He believes the success of OMTD can be attributed to the environment at the event and said he gained a great deal of knowledge and experience with 3-D printing and modeling that he will carry through his career.

"The atmosphere that was created at the rapid innovation event encouraged open communication and free flow of ideas between veteran professionals and new, young talent. Everyone was put into one room to brainstorm, design, innovate and engineer," Ryan said. "It was the most productive environment I have experienced in my professional career so far."

The second week started a full-scale print of the hull, which was produced in six sections and shipped to commercial partner TruDesign, LLC for assembly and post-processing before final delivery to Carderock. Delfin Jose Quijano, a mechanical engineer who works for the Army at Picatinny Arsenal in Wharton, New Jersey, and was a partner at the prototyping event, said the experience was a great one, especially considering everyone's willingness and ability to come together and exchange ideas in productive teams despite just having met. He added that he hopes it leads to more collaboration between the Army and Navy.

As a proof-of-concept hull, OMTD isn't currently operational or testable in the water – this version showed the art of the possible, and that it can indeed be done, according to Kevin Lin, a member of Carderock's Advanced Power and Energy Group (APEG), who created the primary design of the OMTD's energy module with his colleagues Alex Askari and Joseph Curran. The APEG members have worked on several projects that have

been incorporated into OMTD and will be in the future, including the Forward Deployed Energy and Communications Outpost (FDECO), the Non-penetrating Optionally Manned Demonstrator (OMTD's predecessor), and Underwater Wireless Energy Transfer (UnWET), the latter of which won Lin and his colleagues recognition in the 2015 Secretary of the Navy Innovation Awards.

Along with FDECO, a planned underwater wireless charging network for unmanned underwater vehicles like SDVs that would allow them to operate indefinitely, UnWET represents technology that will build upon the progress already made with OMTD.

"The ultimate vision for this system is to create a disposable or limited-use vehicle that can be reconfigured very quickly and has modular energy and data systems," Lin said. "This is not just a 3-D printed vehicle; it's a host of different potential technologies and existing technologies that are integrated into one very awesome working device. Future generations will be able to operate both manned and unmanned, so energy becomes very critical there."

The next version of OMTD will be produced at ORNL and tested at Carderock in fiscal year 2018, with fleet-capable prototypes scheduled to arrive in fiscal year 2019. Mark Johnson, director of DOE's Office of Energy Efficiency and Renewable Energy, Advanced Manufacturing Office, which oversees the MDF, said working with Carderock, an institution possessing deep expertise in naval systems technologies, on this project is a great example of interagency science and technology collaboration achieving accelerated impact of global importance.

"The additive manufacturing materials and processes for the OMTD test article required the deep scientific expertise resulting from years of research and technical capabilities of ORNL through their MDF. This project harkens back to the roots of Oak Ridge when the lab was established to provide critical scientific infrastructure to the Manhattan Project," Johnson said. "Today, the MDF researchers apply supercomputers to model additive processes, neutron sources to image residual stress in structures and nanoscience to investigate new materials that were subsequently used in OMTD. This scientific prowess was on display where the technical issues arising from using the additive process in large naval structures were overcome by the collaborative team."

Johnson said the technical partnership with Carderock and the DTL also benefited ORNL because technical and scientific challenges that arose in planning and execution of the rapid prototype event and test article print gave rise to the next set of additive materials and process research questions to be answered. As these next challenges are overcome, even greater capabilities will be enabled for the Navy, as well as the energy community. Demonstrating a large structural system in this way, he said, provided new insight in addressing challenges in energy.

"These partnerships challenge researchers to think well beyond what is possible with today's technologies and imagine a world where the early-stage research and development in the national laboratory community can most quickly and effectively translate to capabilities serving the national missions in security and energy," Johnson said. "By challenging these outstanding individuals to do something awesome, they have stepped up and we see results. It was an opportunity for each agency to pursue their individual missions, while achieving something pretty incredible together: a 3-D printed submersible."

This extensive, productive collaboration between organizations results from how the DTL has operated since its founding six years ago, according to Shields. From its beginning in a basement office with eight Carderock employees talking about the role of robots on ships, leading to exoskeletons being integrated into naval shipyards, the DTL's network of exchanging unorthodox ideas expanded over time to academia, across the entire Naval Research and Development Establishment and to all the Warfare Centers, multiple branches of the military and other government agencies like DOE and ONR.

"Because we've been exposed to all this technology, we have a different perspective of what a naval vessel can be," Shields said. "We think about things like disposability of ships as assets. We don't think ships should last 30 years; they should last just so long as they prosecute the problem they're trying to solve, then you grind them up and print another one that has different characteristics.

"A lot of the things we are talking about in the DTL aren't going to happen for 65 years. It takes a lot of energy and a lot of money to make these things happen. We built an architecture of trust that says we won't criticize one another's ideas, no matter what it may be or how farfetched. That gets you to the product that goes into the marketplace and that's what will bring this technology to the fleet."

Four other entrants received the NAVSEA Commander's Award for Innovation this year: Kenneth A. Fischer of NSWC Philadelphia; the Supervisor of Shipbuilding, Conversion and Repair Groton, Connecticut's Aged Contract Closeouts Team; and two other entries from Carderock: Establishment of the Manufacturing, Knowledge and Education (MAKE) Lab Team and Radar Cross Section Measurement Systems Upgrade Simultaneous Data Collection.

"By challenging these outstanding individuals to do something awesome, they have stepped up and we see results."

Marines use additive manufacturing to bring innovation to the battlefield

By Daniel Daglis,
Carderock Division Public Affairs

The Marine Corps Innovation Challenge was established to bring new ideas to the warfighter from the warfighter. Several Marines introduced their winning innovations to senior leaders during a presentation session at Naval Surface Warfare Center, Carderock Division in West Bethesda, Maryland, Aug. 15.

Carderock's Additive Manufacturing Project Office, along with the Corrosion and Coatings Engineering Branch, provided support for the competition hosting three of the seven winners – 2nd Lt. Ben Lacount, Staff Sgt. Daniel Diep and Capt. Kyle McCarley – earlier in the year. These Marines were given the opportunity to work with Carderock engineers in the Manufacturing, Knowledge and Education (MAKE) Lab to prototype their ideas using the MAKE Lab's 3-D printers and additional resources.

Capt. Christopher Wood, active duty lead for additive manufacturing (AM) in the Marine Corps, gave the introduction to a crowd including Lt. Gen. Michael G. Dana, deputy commandant for installations and logistics; Maj. Gen Neil "Rick" Nelson, deputy commanding general of the Marine Corps Combat Development Command; Brig. Gen. (Sel) Christian F. Wortman, commanding officer of The Basic School; and Jeannette Evans-Morgis, deputy to the commander of Systems Engineering and Acquisition Logistics at Marine Corps Systems Command.

Lacount gave a presentation on his prototype for an expended rounds counter, nicknamed the "Lacounter," which he developed two prototypes for with the help of Carderock's Bryan Kessel, an engineer from the Additive Manufacturing Project Office.

Lacount came up with the idea because he said that when the warfighter is trying to suppress enemy fire, the last thing on their mind is keeping mental track of how many rounds are left in the weapon. He hopes that with this new device it will provide Marines and other warfighters alike better situational awareness when they're in a combat environment.

"My goal for this project was to have a simple, lightweight, low-cost and no battery solution to this issue," Lacount said. "So what we developed with this team of Carderock engineers is a counter that attaches to any Picatinny rail on a weapons system. This includes your M-16, your M-4, your 249s, 240s and even your 50-caliber machine guns. And the way it does this is either by using the recoil of the weapon by what we call the inertial design, or the lever-action design which will count the rounds as it strikes the brass inside the weapon."

Staff Sgt. Deip, who serves as a maintenance chief stationed at the 14th Marine Regiment, is using his innovation to alleviate a problem he came across while maintaining gear for the Marines. Deip said that a few years ago the Marine Corps decided to modernize the M777 howitzer by adding a piece of technology called the Chief of Section Display (CSD) used for aiming navigation. While it has proved to be a useful tool in aiming such a large piece of artillery with long-rang capabilities, sometimes the cable that attaches the CSD to the weapon can be damaged from debris that gets stuck in the cable and then is further damaged by being jammed on the end of the device.

Deip was able to develop a short cable cap about six inches in length that can easily be plugged into the cable itself and is disposable. Deip added that this is a very cost-effective way to keep the M777

Far left: Matt Huffman (left), a naval engineer with Naval Surface Warfare Center, Carderock Division's Advanced Power and Energy Branch, tells U.S. Marine Lt. Gen. Michael Dana (second from right), Deputy Commandant for Installation and Logistics, Headquarters Marine Corps, and other visiting Marines about innovations in expeditionary solar power during a tour in West Bethesda, Md., Aug. 15, 2017. These Marine leaders were visiting Carderock along with Marines presenting their winning entries from the Marine Innovation Challenge Showcase, an effort launched last year to empower Marines and Sailors to come up with fresh ideas to increase safety and efficiency for their unit or mission. (U.S. Navy photo by Dustin Q. Diaz/Released)

Left U.S. Marine Lt. Gen. Michael G. Dana, (far left), and other visiting U.S. Marine Corps leaders in additive manufacturing watch a welding display put on by Greg Nehl, a welding engineer assigned to Naval Surface Warfare Center, Carderock Division's Welding, Processing and Nondestructive Evaluation Branch, during a tour in West Bethesda, Md., Aug. 15, 2017. (U.S. Navy photo by Dustin Q. Diaz/Released)

Bryan Kessel, an engineer assigned to Naval Surface Warfare Center, Carderock Division's Welding Processing and Nondestructive Evaluation Branch, gives visiting U.S. Marine Corps leadership a tour of the Manufacturing, Knowledge and Education (MAKE) Lab, Carderock's collaborative additive manufacturing facility, in West Bethesda, Md., Aug. 15, 2017. (U.S. Navy photo by Dustin Q. Diaz/Released)

howitzer in the action and from being rendered defective due to the damage to the CSD cable. These cable caps can be produced for around $10, which offers an incredible savings from having to replace the entire cable which Deip estimated to cost around $3,000 and would normally take him a week to repair.

"The neat thing about this cable cap is the cable heads themselves can be additively manufactured, and Marines like myself can take all the old cables, cut them down, and we can put new heads on them after 3-D printing," Deip said.

McCarley visited Carderock most recently May 22-24 where he developed a prototype for his "Bang Bag" which is a modified field backpack that enables the warfighter to easily carry Bangalores, explosive charges used by combat engineers to clear obstacles in the field.

According to McCarley, Bangalore torpedoes are bulky and difficult to take on patrol, but are often used in training to rehearse the breaching fundamentals and conduct an assault breach. With the implementation of a quiver like backpack that he designed with elastic straps that can hold Bangalore torpedoes, flexibility at the tactical level would be afforded to combat engineers when conducting mobility operations. McCarley added that this backpack could be created as a modification to the existing assault pack in the squad demolition kit.

Molnar and Conduto are working to bring AM capabilities to forward-deployed Marines abroad. Molnar, a combat engineer and project officer currently stationed at Marine Corps Systems Command in Quantico, Virginia, wants to bring AM labs directly to the warfighter while also using readily available resources with his product: a recycled plastic processing center.

"It's a 20-foot intermodal container where we can turn plastic bottles, polyethylene terephthalate (PET) plastic right now, from a used bottle into a usable filament that can be used to 3-D print," Molnar said. "This container will benefit the Marine expeditionary units and the Marine Corps and DOD because it can do two things: One, it enhances the expeditionary readiness of forward-deployed units by being able to print parts locally on site using recycled materials, and second, it helps those combat units forward by providing stuff that they can't do, as well as printing stuff for the local populous during humanitarian disaster relief that we couldn't normally do and that we'd have to pay someone to do."

Molnar exhibited a radio bracket that was 3-D printed out of 12 water bottles in just six hours. He added that his team is working on expanding their 3-D printing capabilities using acrylonitrile butadiene styrene (ABS) plastics through additional funding and further modification.

Conduto, an explosive ordnance disposal (EOD) tech currently serving as course chief for the explosive ordnance exploitation course at the EOD Training

Center in California, is also focused on bringing AM capabilities directly to the warfighter. He pointed out that the major problem he sees is that ordnances are constantly evolving; however, the tools that exploit these explosives are not evolving as quickly. His goal with his idea for a deployable fabrication system is to give EOD techs the ability to build their own tools in the field for ordnance exploitation.

"This system consists of 3-D scanner, a 3-D printer for plastic and metal, and a computer numerical controlled (CNC) mill and CNC leg," Conduto said. "All of these items – and this is not new technology by any means – but this is a new application and we're giving it to the EOD tech. The reason we have to do that is because I can't walk down to the Marine Corps machinist with a stinger missile in my hand and say, 'I need a set of tools made, can you get these back to me next week?' There are ordnance-related oddities we have to deal with in the field and I need to be able to do this in house."

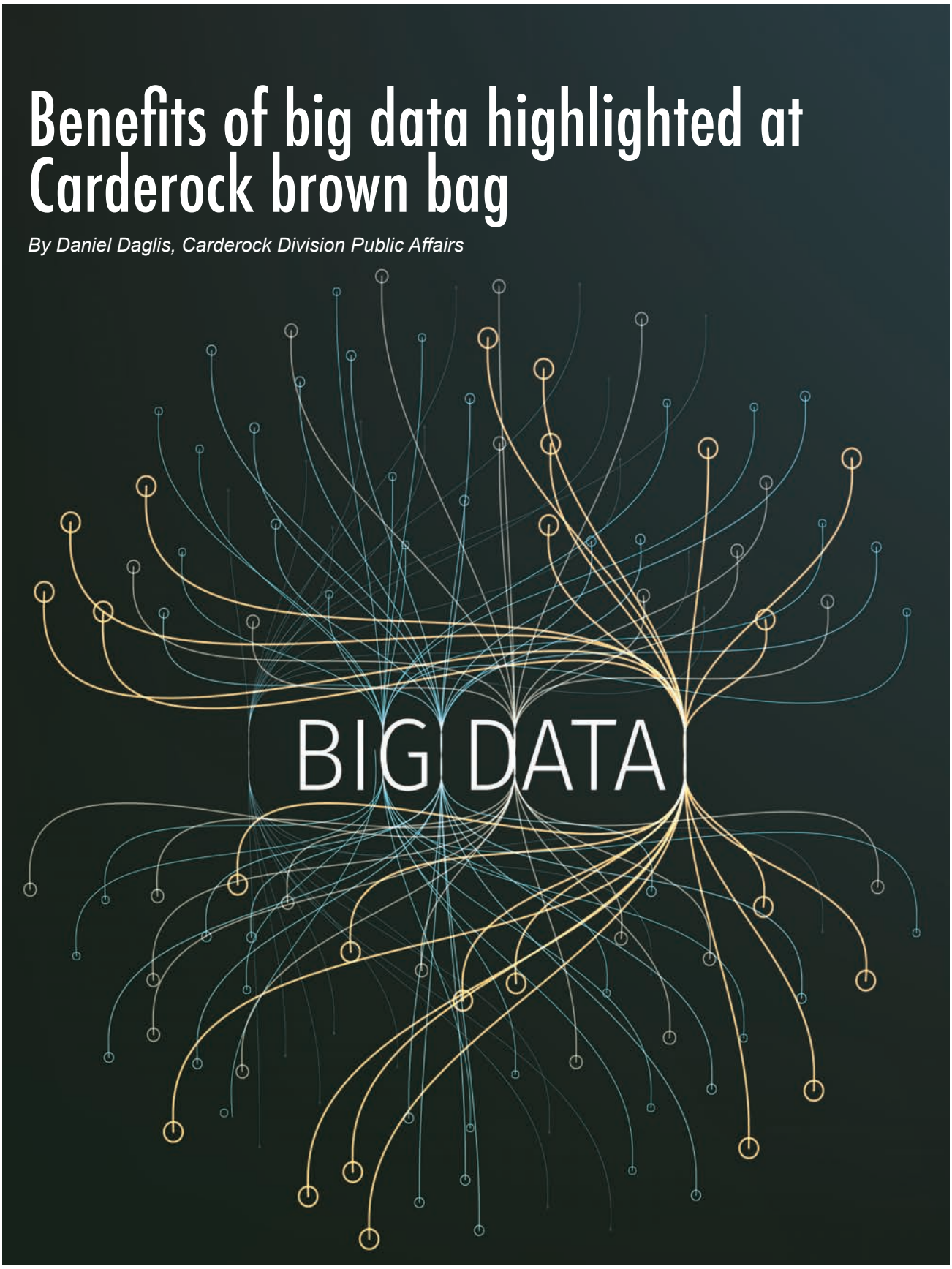
Conduto is currently working with engineers at the Naval Undersea Warfare Center, Keyport Division to build these deployable quick-ready kits to bring directly to the warfighter. He added that these kits will give deployed techs the ability to keep generating the tools they need in a very quick, cost-effective manner.

Following the presentations, the Marine Corps leadership was given a tour of some of the Carderock facilities including the command's MAKE Lab, which offers employees an open workspace to learn AM and the 3-D printing process.

Garry Shields, director of Naval Surface Warfare Center, Carderock Division's Disruptive Technologies Laboratory, tells visiting U.S. Marine Corps leadership about the Optionally Manned Technology Demonstrator, an additively manufactured proof-of-concept submersible hull, during a tour in West Bethesda, Md., Aug. 15, 2017. U.S. Marine Lt. Gen. Michael G. Dana, Deputy Commandant for Installations and Logistics, Headquarters Marine Corps, and other Marine leaders were visiting Carderock along with Marines presenting their winning entries from the Marine Innovation Challenge Showcase, an effort launched last year to empower Marines and Sailors to come up with fresh ideas to increase safety and efficiency for their unit or mission. (U.S. Navy photo by Dustin Q. Diaz/Released)

Benefits of big data highlighted at Carderock brown bag

By Daniel Daglis, Carderock Division Public Affairs



At a brown bag at Naval Surface Warfare Center, Carderock Division in West Bethesda, Maryland, on June 28, Dr. Jonathan Tu, an engineer in the Ship Signatures Department visiting from the detachment in Bangor, shared with colleagues the importance of adopting big data methodologies in their work. Tu said data analytics is not only the definitive way to conduct research in the future, it also is how many major companies today are flourishing in the marketplace.

With a Ph.D. from Princeton University in mechanical and aerospace engineering and degrees from the University of Washington in aeronautics, astronautics and mathematics, Tu made clear that he is not a computer scientist, so his perspective on big data comes from more practical applications.

"We all do data science already. The idea is to bring some of these modern tools to bear in the problems we already have," Tu said. "The most obvious place to think about what you can do with big data is to look to industry because that's really what's driving things and the first place we can look is the online world, something that I'm sure all of us interact with on a day-to-day basis. Whether it's Google, Amazon, Facebook or Twitter – these companies are solving problems through big data."

According to Tu, big data has several applications among many different industries. Tu gave the example of some applications being undertaken in medicine where medical professionals are doing cancer detection and taking algorithms that have been developed in the field of computer vision and applying them to diagnostic tools that look at various medical images, trying to help doctors better identify tumors from these images.

Tu also pointed out how teams in the National Basketball Association (NBA) are using big data to prepare for games. The NBA has traditionally used video assistants to analyze video and identify certain playing habits of other teams. Tu said that by using big data they have been able to analyze a lot more games in a much shorter amount of time.

"The NBA has installed motion-capture cameras in every single arena and they record x-y position on every player in every game. They're trying to do interesting things with this data. Say a videographer who is trained in basketball can identify all pick-and-rolls by watching video footage with close to 100 percent accuracy. They can only watch so many hours of video a day, but maybe they can review four games in the day you have to prep for the team's next game. Instead, you can take this x-y position data of all the players and you can run an algorithm that tries to pick out where all the pick-and-roll plays occur. You will probably do objectively much worse. However, say the data generated by a computer only accurately picks out 80 percent of those pick-and-rolls; with big data they can identify trends and conduct statistical studies on those plays over the course of games played in the last five years. This data ends up being much more powerful than your 100 percent accurate data on only four games, and you acquired it in much less time."

One major reason Tu gave as to why big data needs to be a priority is because data is very cheap to generate in many applications. He cited that technology like sensors and computers are much cheaper to buy and run than in the past.

Steps are already being taken within the command and at other Warfare Centers to build the big data community. Besides Tu, below are some Carderock staff working on this issue:

Nathan Hagan is serving as the digital lead for the Naval Sea Systems Command (NAVSEA) Warfare Center Executive Office. In this role he is coordinating pilot efforts across NAVSEA and building a community of practice across the Warfare Centers aimed at the disciplines of big data analytics, digital twin modeling and simulation, model-based systems engineering, and digital manufacturing and production, including additive manufacturing. This group is actively seeking interested subject-matter experts in these disciplines to work with NAVSEA and the Digital Warfare Office over a series of pilot programs aimed at demonstrating impacts from these methodologies

Jonathan Hopkins is standing up a Digital Design Lab, coordinating with leads in digital design within Carderock to implement a new lab space to experiment with future capabilities.

Dr. Craig Merrill's area of focus is developing the Navy's "digital twin." Digital twin is an integration of data and physics-based models with machine-learning algorithms to enhance the Navy's ability to understand and predict ship performance. He will apply some of the same tools used by big data analytics.

Trisha Shields is standing up a Data Science/Analytics Competency and Community of Practice for Carderock. The goal is to establish a fundamental capability and resource for the workforce to stay in step with current techniques and best practices, as well as help network across codes and Warfare Centers.

Dr. Jonathan Tu discusses the benefits of using big data with department heads, engineers and other leadership at a brown bag at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 28, 2017. (U.S. Navy photo by Daniel Daglis/released)

Carderock, UMBC open door for collaboration with EPA

By Daniel Daglis, Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division Commanding Officer Capt. Mark Vandroff and Technical Director Dr. Tim Arcano joined Carderock's Director of Strategic Relations Dr. John Barkyoumb for the signing of an Educational Partnership Agreement (EPA) with the University of Maryland, Baltimore County (UMBC), on July 27 in West Bethesda, Maryland.

"I'm very excited about this opportunity and really look forward to this being a success for the government, for UMBC and for the students," Arcano said. "This EPA is mutually beneficial because it connects UMBC to Carderock and the government for research purposes and cultivates an environment for collaboration."

The EPA is one of 12 active partnerships that Carderock has with college-level institutions and K-12 public school systems. EPAs are used with young students grade K-12 to promote careers in science, technology, engineering and math (STEM) while agreements with colleges and universities allow for collaboration in research and project efforts. According to Barkyoumb, this new EPA will help to strengthen the relationship with UMBC in areas of cyber security, additive manufacturing and additional business areas.

Representatives from UMBC present for the signing included Vice Provost for Academic Affairs Dr. Antonio Moreira, Dr. Karl Steiner and Dr. Don Engel, vice president and assistant vice president for research, respectively.

Moreira joined Arcano and Vandroff in the signing of the official document. In addition to his position in academic affairs at UMBC, Moreira is also a professor of chemical, biochemical and environmental engineering who spent nearly 10 years in the private sector in senior management positions. He also has an active research program in bioprocess engineering.

"We are very excited about this partnership. We have many partnerships with the Department of the Navy and this is one of the strongest," Moreira said. "We look forward to enhancing this partnership in terms of internships and cooperative research opportunities with faculty. We also look forward to working with Carderock to enhance our status as two powerhouses in innovation. It's terrific to be able to partner Carderock scientists, engineers and staff with our students and faculty as we move along to future objectives."

The term of an EPA spans five years and the purpose of the agreement is to aid in the educational experience of the institution's students by providing a mechanism by which those students can benefit from Carderock's staff expertise, unique facilities and equipment related to surface warfare science and technology. Carderock's contributions to this partnership help to encourage student

Investing
in our future

interest in STEM, and business vocations may benefit Carderock laboratories in terms of advance training of future employees.

"Whenever I talk to new employees at Carderock, I always impress upon them that all business is a people business because it is people that accomplish the missions of the organization," Vandroff said. "Partnerships like this are a way to help us attract great people and maintain a top-notch workforce. This EPA is a great gem in those things we do to help our people both to get the right people here and to keep the right people here."

Under an EPA, Carderock may loan defense laboratory equipment to an institution for educational purposes, make laboratory personnel available to teach science courses or to assist in the development of such courses and related educational material, and offer visits, tours and demonstrations at its facilities for faculty and students of the partnered institution. Additionally, Carderock designates a senior scientist or engineer to be responsible for structuring the partnership program and provide support to the educational institution.

Also present for the signing, and to welcome representatives from UMBC, were mechanical engineers and leaders in Carderock's additive manufacturing initiatives Caroline Scheck and Jonathan Hopkins.

"I think that these partnerships are really important to our mission because the universities have so much new knowledge and are able to innovate quicker in some ways," Hopkins said. "We now have the ability to reach out and really dive deep into our research initiatives. This also allows us as engineers at Carderock to get really good solutions as quickly as possible out to the Navy fleet."

Scheck, a UMBC alumna with a bachelor's and a master's degree in mechanical engineering, has played a key role in additive manufacturing and was given the opportunity to spearhead the organizing of the Naval Additive Manufacturing Technology Interchange – the first meeting of which was held at Carderock in 2014. She now leads the NAVSEA Additive Manufacturing Warfare Center Working Group.

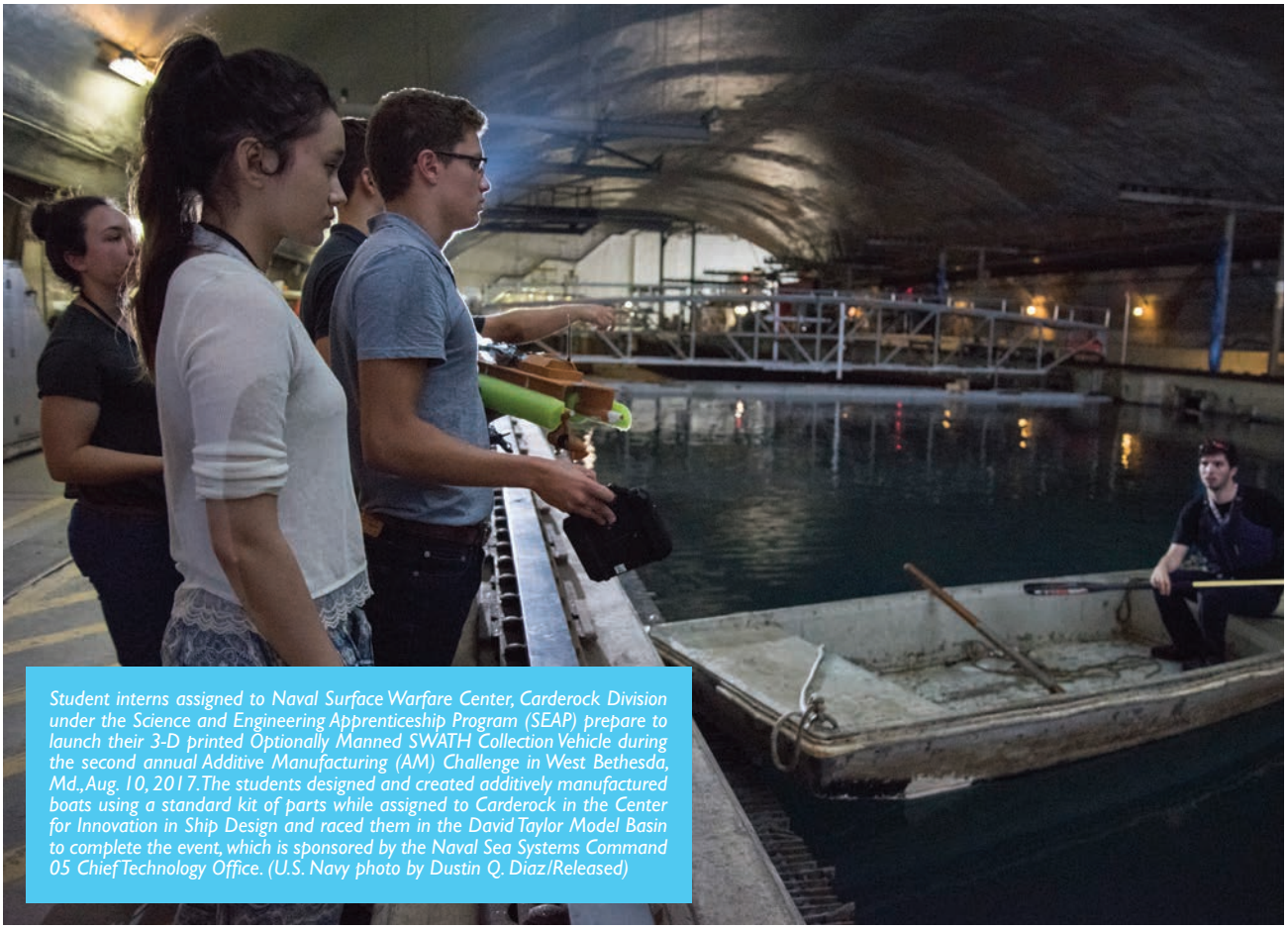
"I'm still currently enrolled as a doctoral student at UMBC," Scheck said. "I have loved the campus, loved the professors, and I'm really happy to see this move forward having come from there and seeing what UMBC can offer in terms of research and expertise."

Following the signing, UMBC representatives were taken on a tour of the Carderock facilities including the Manufacturing, Knowledge and Education (MAKE) lab, which is a workspace for employees to learn about additive manufacturing and the 3-D printing process.

Naval Surface Warfare Center, Carderock Division Commanding Officer Capt. Vandroff and Technical Director Dr. Tim Arcano (right) sign an Educational Partnership Agreement with the University of Maryland, Baltimore County (UMBC), in West Bethesda, Maryland, July 27, 2017. (Seated left to right) UMBC Vice Provost for Academic Affairs Dr. Antonio Moreira, Vandroff and Arcano. (Standing left to right) Carderock Director of Strategic Relations Dr. John Barkyoumb, UMBC Assistant Vice President for Research Dr. Don Engel, Carderock mechanical engineer Caroline Scheck, UMBC Vice President for Research Dr. Karl Steiner and Carderock mechanical engineer Jonathan Hopkins. (U.S. Navy photo by Monica McCoy/Released)

Interns build boats that collect trash, then conquer Carderock's AM Challenge

By Dustin Q. Diaz, Carderock Division Public Affairs and Edvin Hernandez, Public Affairs intern



Student interns assigned to Naval Surface Warfare Center, Carderock Division under the Science and Engineering Apprenticeship Program (SEAP) prepare to launch their 3-D printed Optionally Manned SWATH Collection Vehicle during the second annual Additive Manufacturing (AM) Challenge in West Bethesda, Md., Aug. 10, 2017. The students designed and created additively manufactured boats using a standard kit of parts while assigned to Carderock in the Center for Innovation in Ship Design and raced them in the David Taylor Model Basin to complete the event, which is sponsored by the Naval Sea Systems Command 05 Chief Technology Office. (U.S. Navy photo by Dustin Q. Diaz/Released)

Student interns made a new tradition official when they raced 3-D printed boats they designed and created themselves in the second annual Additive Manufacturing (AM) Challenge on Aug. 10 at Naval Surface Warfare Center, Carderock Division headquarters in West Bethesda, Maryland.

For their summer project, the interns, who were assigned to Carderock this summer under the Science and Engineering Apprenticeship Program (SEAP), were tasked to research and develop concept designs for an ocean vessel that would be able to filter water waste from the oceans' garbage patches.

Accumulation of garbage, also known as garbage patches, in the oceans are made from the waste and plastics discarded by humans and could cause harm to marine life, according to Danielle Kolber, a naval architect with Carderock's Center for Innovation in Ship Design (CISD).

Interns were split into teams responsible for creating an ocean-cleaning vessel (OCV) that would be capable of operating in sea state five to seven conditions. Using the rhino software design program, the interns were able to experience the full model ship-design process before 3-D printing their final product.

"Each team had to come up with their own design in just a few short weeks," said Jonathan Hopkins, a mechanical engineer and Carderock's Additive Manufacturing Project Office lead. "This year, they had to print their own propellers as well, so the students had the opportunity to engage with our hydrodynamics folks to get background knowledge on what to consider when you're doing a prop design from scratch. That was the added challenge for them this summer and they learned a lot from doing that."

One team in particular collaborated with the ship design groups to collectively create and advise on potential filtration devices that could be equipped to the models. Some challenges the teams faced were the way their filtration device would interact and affect marine life, especially with smaller organisms like plankton.

"The plankton is the exact same size as the thing we are trying to collect, so we couldn't think of a good way to not catch any plankton," said intern Nicole Popp. "We thought about ways to try to separate it from the plastic and things like that, but there wasn't a good way to do it. We doubt it would have a significant impact on the plankton population since they reproduce a lot every day."

The Optionally Manned Small Waterline Area Twin Hull (SWATH) Collection Vessel created by interns Jack Lange, Natalie Brooks, Anthony Guardado and Carter Junod was a conveyer-belt design to filter the water while collecting the rubbish.

"We went with the SWATH mainly because of how it handles in rough seas. The way we're picking up the plastic is by a conveyer belt, so we wanted to make sure when the conveyer belt is in the water and operating that it's not being banged around by the wave action. We wanted the platform to be stable," Lange said.

According to Guardado, the team's conveyer belt system was designed to be environmentally friendly.

"We have staggered mesh paddles that allow fish to swim through it while catching the waste," Guardado said.

Fellow team member Brooks said their boat was designed with a wave-piercing hull at the front to protect the conveyer belt from any damages. The multihull design is optionally manned and uses mesh buckets to collect the plastic.

A mono-hull model named Pacific Area Cleanup-Manned Vessel, or PAC-Man, was designed by interns Joshua Grammer, Holly Krynicki, Joe Somerville and Clara Hellersund. The team members said they found several naval architecture components to be quite challenging, but they learned about their model's capability through the practice of their calculations in ship stability and resistance.

"Learning those equations and pretty much the math that goes up to naval architecture – that was critical in designing a ship that was feasible," Somerville said.

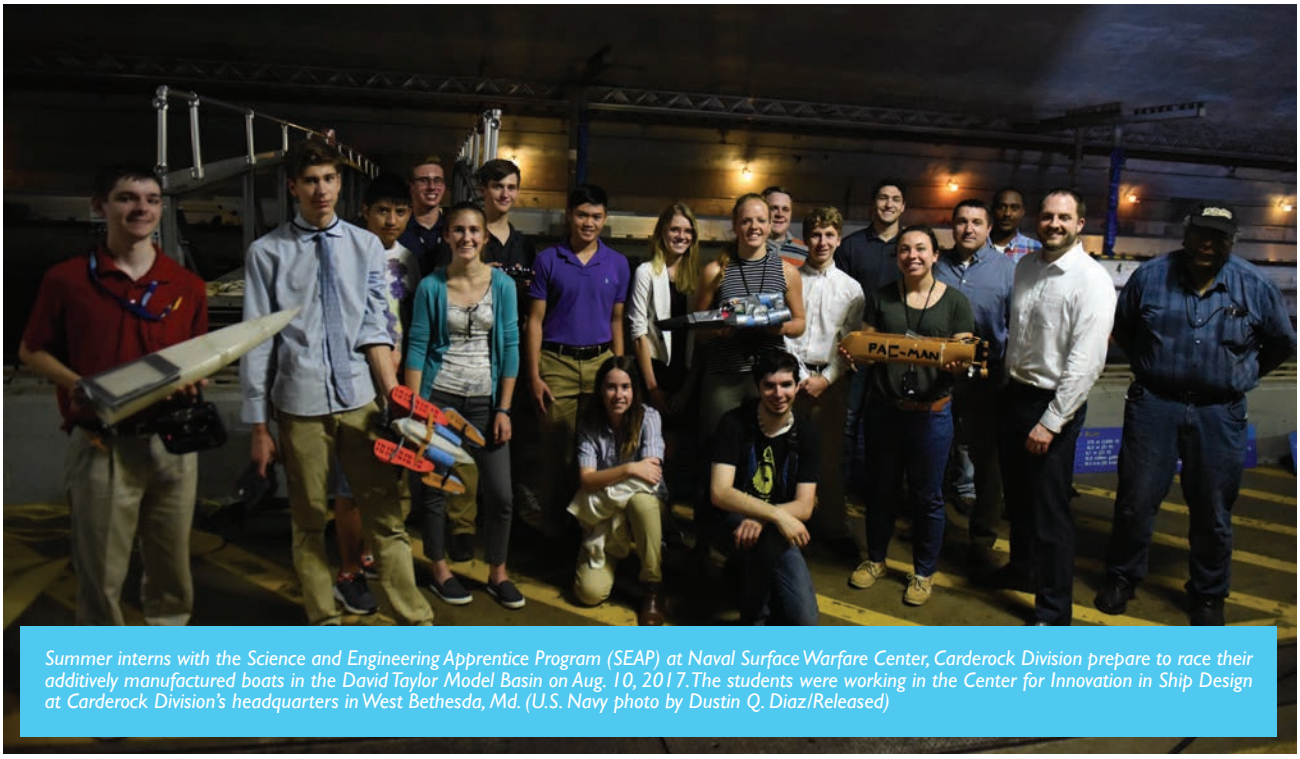
Similar to the SWATH design, the PAC-Man was designed to be environmentally friendly using a net that would pick up trash in the ocean, but allow marine animals to easily escape, according to Krynicki. The PAC-Man team used the offshore supply ship Bourbon Orca as a reference ship when designing their model.

The teams went on to race their vehicles in the David Taylor Model Basin (DTMB) on Aug. 10 for the AM Challenge.

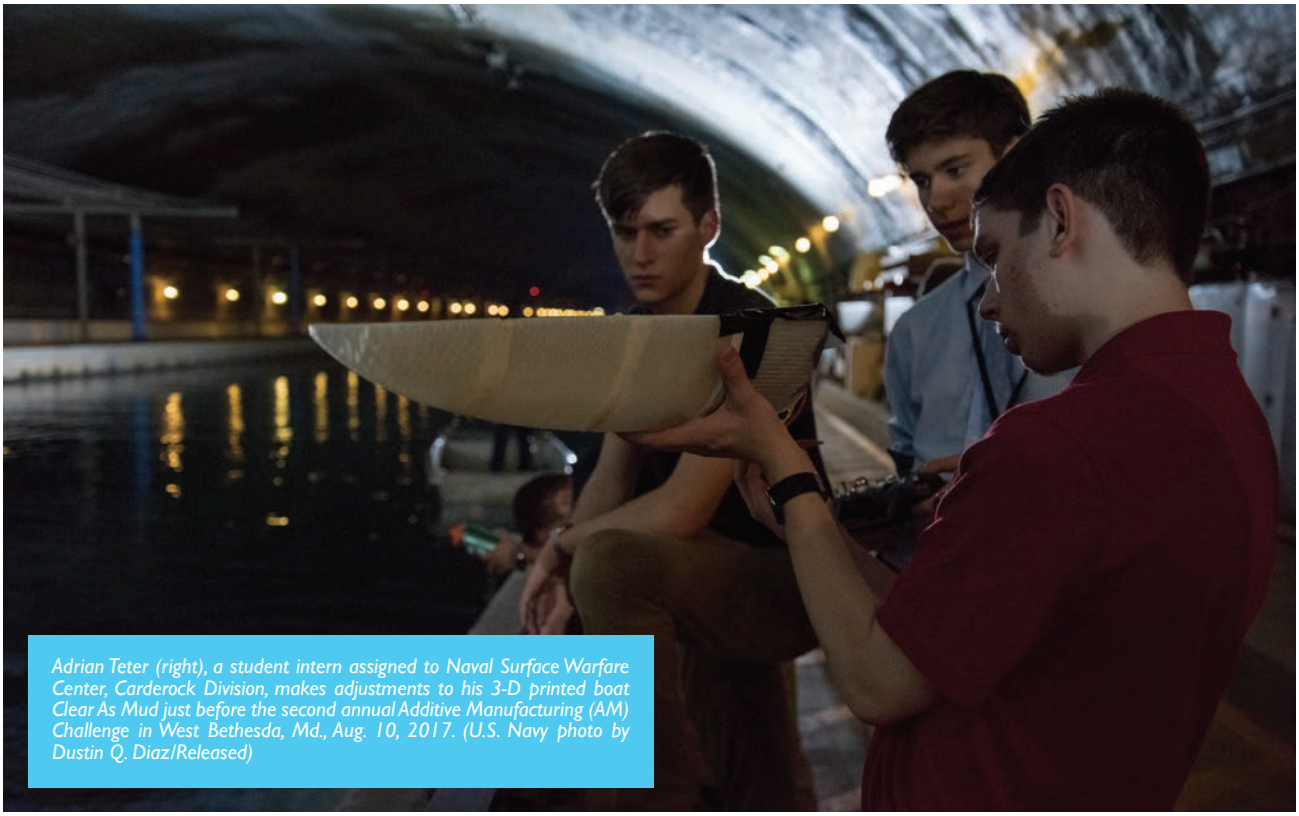
The obstacle course was won by the SWATH team. Although Brooks, a rising senior at Magruder High School in Montgomery County, Maryland, said she wasn't sure if the team's boat would work properly come race time, they're glad it did.

"The motor kept falling off and so did the propellers – we had to solder them back in the last 15 minutes, so it was pretty down to the wire," said Brooks. "But we didn't give up!"

Brooks said she chose Carderock for her internship because of its positive reputation in the engineering world. She said her experience here, including the AM Challenge, far exceeded her expectations, giving her the training and hands-on experience she wanted in the basics of naval architecture and how to handle projects like this one.



Summer interns with the Science and Engineering Apprentice Program (SEAP) at Naval Surface Warfare Center, Carderock Division prepare to race their additively manufactured boats in the David Taylor Model Basin on Aug. 10, 2017. The students were working in the Center for Innovation in Ship Design at Carderock Division's headquarters in West Bethesda, Md. (U.S. Navy photo by Dustin Q. Diaz/Released)



Adrian Teter (right), a student intern assigned to Naval Surface Warfare Center, Carderock Division, makes adjustments to his 3-D printed boat Clear As Mud just before the second annual Additive Manufacturing (AM) Challenge in West Bethesda, Md., Aug. 10, 2017. (U.S. Navy photo by Dustin Q. Diaz/Released)

Like Brooks, Aiden Teter said he was excited for the opportunity to race a craft he made himself in the world-famous DTMB, which he has only seen used before during the International Human-Powered Submarine Races in June. He had only started two weeks prior on his craft Clear As Mud, which won the drag race between all the boats despite one of his four propellers falling off.

"I was worried when that happened, and my craft took on a lot of water, but I kept it at a constant speed and got it to the finish," said Teter, who will begin attending University of Maryland, Baltimore County following his internship and was the lone member of his team, though he still had help from other interns. "I've never gotten to 3-D print anything this large before, and then to actually come in first in the drag race was a lot of fun."

Four teams altogether tested their creations against the other boats, with about twice as many students participating as last year's AM Challenge, according to Hopkins. Though they all had mechanical issues to troubleshoot, Kolber said their ability to persevere and be successful speaks highly of the students, especially since they worked collaboratively while competing against each other.

"We typically encourage them, if they have a problem or hit a hiccup in their process to re-navigate and figure out what is causing the issue and then go from there," Kolber said. "Not only were they able to balance completing this challenge with their other projects for the summer, they were able to adjust when they have problems with their boats, get them working and complete the challenge. They did an excellent job."

Hopkins said the AM intern summer projects and the AM Challenge remain essentially a pilot program in this early state that will help Carderock's Additive Manufacturing Project Office learn what is achievable in a short period of time with AM and what different printers are capable of. He hopes the team can develop a package they can send to schools so they can grow their own programs. Under this plan, those students could then also come to Carderock for testing and further learning from the command's technical experts, similar to its other science, technology, engineering and mathematics (STEM) outreach programs like SeaGlide, SeaPlane and SeaPerch.

NAVSEA 05T1 Program Manager Danesha Gross, who sponsored both year's AM Challenges, attended the inaugural event last year and said she was elated to see the students, some of whom had never heard of 3-D printing before the competition, learning creative design via the AM process.

"These are the types of learning environments that should be showcased more at NAVSEA," Gross said. "I look forward to working more with our STEM teams at the Warfare Centers and discovering different characteristics."

These members of Carderock's Manufacturing, Knowledge, and Education (MAKE) Lab team also supported the event: Kent Bartlett, Michael Britt-Crane, Jovan Brown, Grant Honecker, Hopkins, Jeeven Hugh, Bryan Kessel, Kevin Lin and Sam Pratt.

Read about last year's AM Challenge and see photos at https://www.dvidshub.net/news/224538/carderock-interns-pilot-navsea-additive-manufacturing-challenge.

Summer education workshop at Carderock

By Edvin Hernandez, Carderock Division Public Affairs intern

Teachers from across the country on tour with the Missile Defense Agency (MDA) were welcomed at Naval Surface Warfare Center, Carderock Division for a STEM education workshop held at the Maritime Technology and Information Center (MTIC) on July 20. The overall objective of the MDA tours to train teachers on what STEM is and what government agencies offer interactive programs.

Carderock Program Analyst Odean Cameron led a tour of the group as they visited some of Carderock's facilities, including Carderock's model woodshop, before giving a presentation about the base's outreach programs.

On the tour in West Bethesda, Maryland, MDA's visiting instructors were shown parts of a model ship constructed by engineers and Naval Research Enterprise Internship Program (NREIP) interns that, when assembled, created a complete prototypical vessel. A 3-D printed propeller from one of the models in the shop was presented by Cameron to the visitors. As the group observed the work on display, she explained to them the time, precision and creativity that is involved with the process of each newly assembled ship design.

Back at the MTIC, Melanie Zajic, a chemical engineer, presented her experiences as an engineer working with younger children. In the past, Zajic has worked with children on constructing Bristlebots and the SeaPerch, which are fun STEM challenges they tackled while visiting with their schools. Cameron expanded on Carderock's outreach programs by highlighting the base's effort and commitment in encouraging STEM programs to local students. One of the most frequent areas to host and visit Carderock engineers is the Montgomery County Public Schools district, which neighbors the base.

Carderock has an economic impact on Montgomery County and "a large number of students participate in the SeaPerch program, but we also promote and have schools participate in other student activities and programs," Cameron said. Students in the Baltimore County, Howard County and Fairfax County school systems join Montgomery County students in STEM participation at Carderock.

Melanie Zajic, a chemical engineer at Naval Surface Warfare Center, Carderock Division, presents the SeaPerch model and Carderock's STEM outreach programs to teachers on a tour with the Missile Defense Agency (MDA) on July 20, 2017. (U.S. Navy photo by Edvin Hernandez/Released)

Along with Bristlebots and the SeaPerch developments, related programs like the SeaPlane and SeaGlide are among projects that embody the educational partnership Carderock has with affiliated schools. The SeaGlide is a small-scale underwater glider that has no propeller and moves depending on its buoyancy change, causing the glider to rise or sink in the water. Older students, usually in high school, are assigned this project to complete when they visit the base. Earlier this year, Carderock received recognition for the SeaGlide Program and was awarded a trademark.

The SeaPlane is a project designed for younger children at an elementary-school level. Students build a model gilder before testing how far it can fly. The challenge is intended to teach and excite students about aviation, aerodynamics, engineering, history and design as they test and learn from each attempt. "STEM provides an opportunity for students to learn about real applications of math, engineering and science," Cameron said, adding that the programs give students the chance to think like an engineer as they practice their problem solving skills and find ways to further develop their creativity in improving their models.

Teachers interested in learning how to integrate these assignments into their lesson plans are encouraged to arrange a time and date to visit Carderock to receive training. In the event that teachers cannot come to base, Carderock will send a volunteer engineer to the school and conduct the training lessons there. Throughout the year, engineers on base from different concentrations devote some of their time teaching elementary and middle school children how to design and properly test their own ships. Towards the latter end of the school year, Carderock's David Taylor Model Basin regularly hosts school field trips where students show off and test their semester long school projects in front of Carderock engineers.

Other outreach programs, such as the Carderock Math Contest, are competitions hosted on base and provide elementary and middle school students the opportunity to engage their curiosity and demonstrate their STEM skills. Carderock also provides internship programs to high school and college students. These programs, the Science Engineering Apprenticeship Program (SEAP) and the Naval Research Enterprise Internship Program (NREIP), give students first-hand experience on how the work they do aides the Navy. The internships "provide a possible future employee for the center," Cameron said.

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