



WAVES



YEAR IN REVIEW

2021

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The aircraft carrier USS Gerald R. Ford (CVN 78) successfully completes the third and final scheduled explosive event for Full Ship Shock Trials while underway in the Atlantic Ocean on Aug. 8, 2021. The U.S. Navy conducts shock trials of new ship designs using live explosives to confirm that its warships can continue to meet demanding mission requirements under harsh conditions they may encounter in battle. See story on page 4. (U.S. Navy photo by Mass Communication Specialist 3rd Class Novalee Manzella)

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With 2021 behind us, we've successfully made it through another year! The COVID-19 pandemic continued to pose several challenges, and while it doesn't appear to be going away anytime soon, I am very proud of the way we as a Warfare Center Division remained focused on our mission and adapted to meet the Fleet's requirements.

Several of the stories in this year's edition of WAVES feature the incredible work you all have been able to do in the midst of this ongoing pandemic.

Each and every one of you – whether here at West Bethesda or at our Detachment sites – have shown tremendous dedication to the fleet and our mission during this unprecedented time. Our workforce has shown a resilience during the pandemic to not get comfortable, and to strive to always come up with bigger and better ideas. Our innovation is on full display in this edition of WAVES, and that is something that gives me the most pride about being your Technical Director.

Featured in this edition of WAVES are excellent stories from all different aspects of Naval Surface Warfare Center, Carderock Division, including several patents, a multitude of innovation projects ranging from a full ship shock trial to one of my favorite innovation events — the ANTX — STEM initiatives as well as different important happenings across Carderock in 2021. It is always nice to have outlets such as Wavelets and WAVES to be able to display and recognize the hard work our folks are doing.

From Capt. Todd E. Hutchison, and myself, we sincerely thank the entire Carderock team for your dedication and perseverance through what was another exceptionally challenging year. We are both incredibly proud of your efforts throughout 2021, and are excited to see what we will achieve together in 2022!

Thank you,



MEGAN MCARTHUR
NASA ASTRONAUT, CREW-2

Carderock Participates in Full Ship Shock Trial

By Todd A. Hurley, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center (NSWC), Carderock Division led a Full Ship Shock Trial (FSST) for USS Gerald R. Ford (CVN 78) off Mayport, Florida, this summer, with the three explosive events taking place during July and August.

The FSST was a live fire event to validate USS Ford's shock hardness and to ensure its ability to sustain operations while in a combat environment. Key FSST participants that made up the technical team came from Carderock, NSWC's Philadelphia Division and Dahlgren Division, Naval Air Systems Command, Naval Sea Systems Command 05P1, 05V and 08 among others. In total, including the crewmembers aboard USS Ford, more than 3,000 individuals were involved in the FSST.

Carderock has supported FSSTs for more than 30 years, with the last four being Carderock-led.

Carderock's Joe Venne, the Program Manager for the Underwater Explosion Tests and Trials Program Office, had the position of Shock Trial Director for the Landing Platform Dock, two Littoral Combat Ships and the most recent USS Ford FSST.

"I led the technical team from all the organizations that supported the shock trials," Venne said. We brought all the entities together to form one cohesive team that not only executed the shot and recorded the data, but then performed all of the system evaluations to understand how the ship systems responded to the shot event. Ford is the largest ship we've ever tested and the most complex in terms of new systems. This was the first FSST executed on an aircraft carrier since 1987 with USS Theodore Roosevelt (CVN 71), so this was quite a big deal."

In addition to leading the event, Carderock personnel were responsible for ensuring the three 40,000 pound charges were deployed, and that they detonated properly in the correct locations. Lana Craig, the Explosive Operation Supervisor in Carderock's Dynamic Measurements and Testing Branch, led the explosive operations for the trial and

was ultimately the person who detonated the three 40,000 pound charges.

"The experience of detonating the explosives was awesome; it was a beautiful thing," Craig said. "These were the biggest charges I have ever detonated in my entire life. Being on the bridge of the Explosive Operations Vessel and being able to be the one to push the button was sweet — it was definitely the highlight of my entire career. I don't think there could be anything more exciting than doing this."

Originally an armor handler, it wasn't until the 2016 FSST with the Littoral Combat ships, USS Milwaukee (LCS 5) and USS Jackson (LCS 6) that Craig became an Explosive Operation Supervisor.

"In order to do any explosive operations, you must have an Explosive Operations Supervisor present," she said. "That's why I was brought on to support and execute this mission."

Although the test execution for the event

started in May, the days of the actual shot are the tensest, according to Venne.

"There is so much planning that goes on for months beforehand, but shot day is always such a crazy day," Venne said. "We started each shot day at 0400. We'd check on the sea conditions, and if they met our requirements we would start the charge deployment in the dark. We would then work for the next several hours getting the detonators installed and then taking the 40,000 pound charge, which is hanging from an A-frame, and deploy it 100 feet below the ship suspended from a float, and then pay out the tow cable to 3,000 feet away from the ship."

Additionally, there was an environment mitigation team present, consisting of 10 individuals who would stand on the flight deck and check for marine mammals. They were also supported by a Marine Animal Response Team Vessel and aerial observers.

"If they were to sight any marine life we would





have to take appropriate measures,” Venne said. “That could potentially be cause for a delay, leading to even more stress for all involved. The final hour of countdown was the most intense — figuring out course and speed changes to pinpoint exactly where we needed to detonate the charge was crucial.”

Among those present was Rear Adm. James Downey, Deputy Commander, Surface Warfare Commander, Navy Regional Maintenance Center, who was present for two

The aircraft carrier USS Gerald R. Ford (CVN 78) completes the first scheduled explosive event of Full Ship Shock Trials while underway in the Atlantic Ocean, June 18, 2021. The U.S. Navy conducts shock trials of new ship designs using live explosives to confirm that our warships can continue to meet demanding mission requirements under harsh conditions they might encounter in battle. (U.S. Navy photo by Mass Communication Specialist 3rd Class Zachary Melvin)

of the three shots. The FSST was supported by the Navy Department of Test and Evaluation (DOT&E), with engineers directly supporting the post-shot system evaluations, and also by DOT&E and NAVSEA 05P, 05V and 08 Executive Leadership who were present during the shots.

“Maneuvering the ship to get it into the right position was difficult,” Venne said. “But the officers and crew aboard USS Ford were excellent professionals. Once we got the shot detonated with the ship at General Quarters, the ship went into post-shot ‘fight-through,’ and then we assessed system and mission keeping performance. For days after each shot we would diagnose issues that came up and repair the ship. It was a huge effort to restore the ship to combat capability before each shot, but, in the end, everyone was pleased with the FSST results, especially Rear Adm. Downey and DOT&E.”

Amidst the stress-inducing particularities, each of the three explosive events went as planned.

“Shot day is an extreme event,” Venne said. “It’s exhilarating. I can’t think of anything else I would rather do than execute this type of event with these people. It is real-deal stuff.

The aircraft carrier USS Gerald R. Ford (CVN 78) successfully completes the third and final scheduled explosive event for Full Ship Shock Trials while underway in the Atlantic Ocean on Aug. 8, 2021. The U.S. Navy conducts shock trials of new ship designs using live explosives to confirm that its warships can continue to meet demanding mission requirements under harsh conditions they may encounter in battle. (U.S. Navy photo by Mass Communication Specialist 3rd Class Jackson Adkins)

This is what drives us — knowing that the work we do does make a difference, knowing this could happen in real life and that we could potentially help save lives is what the game is all about.”

Now that the three explosive events have concluded, the next step is to take the recorded data and file a report, which will take place over the next year and will highlight the findings and document everything covered during the FSST.

INNOVATION

AT WORK



Guided-missile destroyer USS Zumwalt (DDG 1000) cuts through Sea State 6 conditions during Rough Water Trials on Oct. 25, 2020. A cloud of spray engulfed the bow as a result of pitch motion and high winds. A team of engineers from Naval Surface Warfare Centers, Carderock Division and Philadelphia Division traveled to the West Coast to execute these trials in October 2020. In April and May 2021, the group replicated the conditions of the second phase of Rough-Water Trials at model scale in Carderock's Maneuvering and Seakeeping Basin. This included reproducing the wave environments and the ship loading conditions for a seakeeping correlation test. This enabled them to quantify the difference between the model-scale predictions and their observations at full scale. This marked the first test of its kind at Carderock and established a new capability. (U.S. Navy photo provided by Steve Minnich)

Naval Surface Warfare Center, Carderock Division and Philadelphia Division employees take a group photo on the bow of USS Zumwalt (DDG 1000) while in port on Nov. 8, 2020, in Everett, Wash. Standing left to right (back row): Samantha Lee, Steven Miller, Justin Harler, Stephen Minnich, Gifford Williams, R. Christian Henes, Richard Bishop, Dr. Alysson Mondoro and Dr. Jeffrey Campana. Kneeling left to right (front row): Michael Mazzaella, Brian Chirozzi and Brandon Dias. (U.S. Navy photo provided by Steve Minnich)

Carderock Engineers Support Rough-Water Trials on West Coast

By Edwin Hernandez, NSWC Carderock Division Public Affairs

In the fall of 2020, a team of engineers from Naval Surface Warfare Centers, Carderock Division and Philadelphia Division flew across the United States to execute Rough-Water Trials on USS Zumwalt (DDG 1000). The trial evaluated the seakeeping and structural response of DDG 1000 and was conducted under the Performance and Special Trials (P&ST) program, which is a collection of tests to develop class-baseline hydrodynamic, structural and machinery performance information.

Separated into two phases, the first phase of the Rough-Water Trials was performed in October 2019. The team evaluated the seakeeping behavior, structural response and operability of DDG 1000 in mission-relevant conditions in Sea States 3, 4 and 5. This assessment also evaluated how the ship motion conditions affect crew performance.

During the second phase of the Rough-Water Trials in October and November 2020, the trials team tested DDG 1000 in more severe wave conditions. The trial was conducted across two storm events, the first near San Francisco, which peaked at mid-Sea State 6 wave conditions, and the second near Ketchikan, Alaska, which produced conditions through the top of Sea State 6. The storm-driven conditions exceeded expectations in terms of exposure time and wave steepness and enabled the team to satisfy all objectives of the testing.

Unlike the Calm-Water Trials, which were conducted near San Clemente Island close to the ship's homeport of San Diego, the Rough-Water Trials required conditions that were not benign. Carderock's Rough-Water Trials Director, Stephen Minnich, explained why his team chose to move further north for the second phase of trials, citing a good rule of thumb: storm intensity tends to increase the further north you go in the Eastern Pacific. Wave climatology studies informed the selection of test locations and schedule to increase the likelihood of finding the required wave conditions. The team used a variety of

wave forecasting models to guide the actual execution of testing.

"We chose locations and times to conduct the testing that would correspond with what forecast models were indicating would provide the wave conditions required to complete our test matrix," Minnich said. "We deployed wave buoys that drifted on the sea surface, which helped us to quantify the seaway in terms of the wave height, period, and direction. We were completely at the mercy of Mother Nature during the testing, but those devices were critically important to the characterization of what we were seeing in terms of ship motion and structural response and for the situational awareness they provided to support safe execution of the testing."

Minnich and his team were encouraged by the results of the Rough-Water Trials, noting that there were no exceedances of critical motion criteria limits. This is important because it confirmed prior characterization of the seakeeping behavior of DDG 1000 in severe wave environments. In early November 2020, the team disembarked in Everett, Washington, after more than two weeks onboard for the trial. The conclusion of the second phase of the Rough-Water Trials means that all of the at-sea testing for the P&ST program is now complete.

In April and May 2021, the group replicated the conditions of the second phase of Rough-Water Trials at model scale in Carderock's Maneuvering and Seakeeping Basin. This included reproducing the wave environments and the ship loading conditions for a seakeeping correlation test. According to Minnich, this enabled them to quantify the difference between the model-scale predictions and their observations at full scale. This marked the first test of its kind at Carderock and established a new capability.

Minnich said he appreciated the team's dedication, time and sacrifice – especially in an elevated risk scenario. The team was

away from home for nearly four weeks to support the trials in the midst of the ongoing COVID-19 pandemic. In spite of the personal discomfort of conducting Rough-Water Trials, Minnich said the entire team rose to the challenge and executed the test successfully.

“We deployed wave buoys that drifted on the sea surface, which helped us to quantify the seaway in terms of the wave height, period, and direction. We were completely at the mercy of Mother Nature during the testing, but those devices were critically important to the characterization of what we were seeing in terms of ship motion and structural response and for the situational awareness they provided to support safe execution of the testing.”

Carderock Assists in Drafting Guidelines on Second-Generation Intact Stability

By Todd A. Hurley, NSW Carderock Division Public Affairs

The International Maritime Organization (IMO) has published the first of a set of two documents on the topic of second-generation intact stability criteria. Published on Dec. 10, 2020, the first document covers the interim guidelines that introduces new regulations for trial use – specifically five ship failure modes – while the second document, set to be released in 2022, will contain explanatory notes.

Intact stability refers to a ship that is in its normal operation configuration – it is functioning as intended and without

consideration of unintended flooding or the accumulation of water where it is not supposed to be.

The purpose of these guidelines is to enable the use of the second-generation intact stability criteria for the assessment of dynamic stability failure modes in waves, which was requested in the 2008 Intact Stability Code. Furthermore, the primary purpose of these documents is to enable the use of the latest numerical simulation techniques for evaluating the safety levels of ships from an intact stability standpoint.

In developing these guidelines, it has been recognized that by combining design methods and operational measures is the most effective way for properly addressing and continuously improving safety against accidents related to stability for ships. The second-generation intact stability criteria should be used for helping to ensure a uniform international level of safety of ships with respect to dynamic stability failure modes in waves.

The five failure modes represented in the second-generation intact stability criteria are: dead ship condition, excessive acceleration,



pure loss of stability, parametric rolling and surf-riding/broaching.

Naval Surface Warfare Center, Carderock Division's Dr. Vadim Belenky, a naval architect in Carderock's Simulations and Analysis Branch, got started working towards this agenda alongside the Coast Guard in 2005.

"In 2005 I started working alongside the Coast Guard in second-generation intact stability," Belenky said. "From there I was involved with problems related to dynamic stability, but have always kept my Coast Guard connections. With the support of Carderock's management and the Coast Guard's funding, Carderock was able to start supporting these developments."

Belenky, a Russian native who grew up along the Baltic Sea, came to the United States in 1996 and started working for Carderock in 2008.

"My original background was in the stability of fishing vessels – my main specialty was dynamic stability," Belenky said. "While working in Russia, we had similar problems with some of our ships, which is why I was hired by Carderock."

Belenky's Coast Guard counterpart, William Peters, a naval architect in the U.S. Coast Guard's Office of Design and Engineering Standards, has been involved with the second-generation intact stability for the last 15 years.

"Certain forces may cause a ship to be disabled or to take on a list or to capsize," Peters said. "These last two are considered bad – we don't want them to happen. The IMO began in 1960 to look at what kind of things could be done to resolve this. They developed standards based on ships who had and had not had casualties and then compared stability characteristics and developed certain standards. If you met this standard, you were likely to not have intact stability failure."

As technical progress has occurred, the shape and sizes of ships has changed.

"With that change came greater occurrence of stability failures," Peters said. "Certain types of things became more and more obvious, which has led to the understanding of these five kinds of stability failures."

The USS Lake Champlain seen in heavy seas off Cape Horn from the USS Independence (CVA 62), fall of 1988. The Champlain's Hurricane Bow was ripped off in this storm.

The push to have an increase in modern vessels' intact stability has been going on for the last 50 years.

"The IMO is not the fastest organization in the world, and things like the second-generation intact stability criteria usually happens once in a generation," Belenky said. "So being approved last December, it is still big news."

Though there has been a growing increase over the last half-century, there has been a stronger sense of urgency since 1998.

"In the late 20th century, we started seeing strange things happening with very large ships – things that would not be expected to have problems," Belenky said. "The interest to intact dynamic stability of modern vessels was ignited by a large-scale container loss that occurred on board the U.S.-flagged container ship, MV APL China, in October 1998."

The China experienced heavy roll motions with a port and starboard roll as great as 35-40 degrees. Of the 1,300 hundred containers on deck, one-third were lost overboard, and another third incurred differing degrees of damage and loss.

"The root cause of the incident was a parametric roll resonance appearing in certain combination of speed, conditions, heading and sea state," Belenky said. "Billions of dollars were lost altogether. This case is similar to the Titanic in that a push was made for greater maritime safety."

However, container ships are not the only ships vulnerable to parametric roll. In 2008, a cruise ship – then known as the Pacific Sun – rolled heavily while in gale force winds and high seas. Of the 1,730 passengers and 671 crew on board, 77 were injured with seven sustaining major injuries.

An instance involving pure loss of stability occurred in 2006 with the Swedish Ro-Ro ship, MV Finnbirch. The Finnbirch experienced heavy seas which heeled suddenly and considerably to port. The list after recovery was 30-35 degrees, causing the ship to capsize and sink. Two lives were lost, and 11 crewmembers suffered severe injuries.

"Stability failure can be either partial or total," Peters said. "Partial failure can be where a ship doesn't capsize, but significant events occur that causes not just cargo, but material, men and or equipment to shift on board, so that afterward you don't have full operability."

A similar instance took place earlier the same year, when, in heavy weather, the rail ferry Aratere experienced heavy rolling on two separate occasions – 50 degrees and 30 degrees – which resulted in five of the 381 personnel

on board being injured.

Another phenomenon – excessive acceleration – can be equally as hazardous. In two separate instances in 2008 and 2009, the German container ship MV Chicago Express and the MV Guayas suffered from excessive acceleration, resulting in two deaths and another serious injury.

Surf-riding/broaching-to is when a ship is unable to maintain a constant course despite efforts of maximum steering. In 2012, the MV Rabaul Queen capsized due to broaching-to. The final death-toll is unknown as the exact number of passengers is unknown, but it is estimated that anywhere from 142-161 individuals perished.

"Surfers do on purpose what ships don't want to do – surf on a wave," Peters said. "The reason is that the stability of a ship in a surf-riding condition is very low, with a high likelihood that something will cause it to turn quickly and capsize. We found that this is still a matter of concern that has never been addressed adequately in other standards, so we wanted to address it."

These accidents alone resulted in the deaths of at least 146 individuals and 98 additional injured personnel. Three of the ships sank. These instances have resulted in the push for an increase in modern vessels' intact stability. The second-generation IMO intact stability criteria are pivotal for addressing the reasons for these accidents.

"The agenda to get this issue resolved started in 2002 – it took some time to realize this was happening more and more frequently," Belenky said. "One of biggest challenges was trying to put the big picture together. It is only now that it is slowly being understood more."

The second document is currently being worked on by the IMO subcommittee and is tentatively set to be approved in May 2022. It is currently already in the trial use stage, with universities and consulting companies performing the trials. The second document will not change anything in the first document, rather, it will further explain it and provide in-depth examples.

"When a ship sinks, we know exactly why – too much water got inside," Peters said. "Why the water got inside is what we have to investigate and figure out. That's what we are doing with this second-generation intact stability criteria."

Portable Vacuum Blast Boosts Productivity for USMC and Carderock

By NSW Carderock Division Public Affairs

The Marine Corps Corrosion Prevention and Control (CPAC) Program operates Corrosion Repair Facilities (CRFs) throughout the world in locations such as Camp Lejeune, North Carolina; Camp Pendleton, California; Camp Kinser, Okinawa; and Marine Corps Base, Hawaii. In the performance of its mission and in an effort to mitigate the damaging effects of corrosion and extend the useful life of equipment, the CPAC program has partnered with Naval Surface Warfare Center, Carderock Division to identify and research corrosion repair capabilities to make it effective and efficient while complying with environmental and safety regulations.

CRFs are utilized to provide field-level intermediate corrosion mitigation on ground vehicles and tactical support equipment. The main repair process involves surface preparation via abrasive blast followed by application of the Chemical Agent Resistant Coating system. It is a multi-step process and access to the blast booth is a known process constraint.

In an effort to work around the blast booth constraint, the Marine Corps' CPAC program teamed with the Office of the Secretary of Defense to investigate the benefits of using a portable vacuum blast system. Carderock led the research into the system.

The portable vacuum blast system is a self-contained blast capability in which material is reclaimed at the point of application. This is done utilizing shrouds of bristle material, which prevent the blast abrasive from escaping. The shrouds come in various shapes and sizes to allow for different substrate configurations, such as corners and small crevices. The blast abrasive is then recycled within the system and is available for use.

Due to its ability to prevent loss of abrasive from the blast process and the small quantity (less than 3 cubic feet) of material that is utilized in the system, the portable vacuum blast unit is exempt from the air quality regulations that require abrasive blast operations to be performed within a regulated booth. This opens the door to many

possibilities of use for the portable vacuum blast system.

CRFs perform a critical function in extending the life of Marine Corps equipment, and they face the challenge of managing production with space limitation.

"During the corrosion repair process, managing production is like a jigsaw puzzle where you're trying to move an asset out of one place so you can blast it, and move it to another place to paint it," Carderock's Eric Moffatt said, a materials engineer Corrosion and Coatings Engineering Branch.

One of the most important aspects of this repair process is time. All of the USMC CRFs have a single blast booth capability with multiple paint booths. Therefore, the blast booth often becomes the limiting factor with the amount of production that a CRF can take on. Utilizing the portable vacuum blast system allows the CRF to blast outside of the blast booth – increasing its capacity for throughput.

"With this system, you're able to keep equipment out of the blast booth and focus on the affected area," Moffatt said. "This allows efficient production and encourages uninterrupted process flow. Ultimately, this capability can be used on most of the assets that come through a CRF, though it is best suited for small area repairs."

One major advantage this system offers is the ability to target spot repairs, which saves time and space. Instead of stripping the coating system from an entire asset, the portable vacuum blast system enables CRFs to perform condition-based maintenance when removing coatings.

As a result of this study, the portable vacuum blast system has been deployed for use in all CRFs operated by the Marine Corps.

"The vacuum blast system at II Marine Expeditionary Force (MEF) CRF has been a significant enabler," II MEF CRF Manager Charles Wolfe said. "During the facility upgrades, in which the blast booth was down

“During the corrosion repair process, managing production is like a jigsaw puzzle where you’re trying to move an asset out of one place so you can blast it, and move it to another place to paint it.”

for over six weeks, the II MEF CRF used the system extensively. The vacuum blast system allowed II MEF CRF to work on items with localized scaling, flaking, pitting corrosion and areas that would normally require the blast booth. The system significantly mitigated the single point failure of our one and only blast booth.”

Beyond use to promote throughput at the CRFs, USMC CPAC is beginning to realize the full potential of the system for repairs accomplished “on-the-lot.” Recently, the



Amphibious Assault Vehicle (AAV) Program Manager approached the CPAC Team for its support of the Common Remotely Operated Weapons Station (CROWS) upgrade for the AAV platform. The portable vacuum blast unit proved to be a force multiplier compared to the use of traditional coating and paint removal tools, which were found to be ineffective/inefficient. Use of the system drastically decreased overall labor costs for the AAV CROWS upgrade versus the use of traditional coatings removal tools by decreasing the time required to remove coatings. So far, the portable vacuum blast system has reduced planned labor hours for a single asset by 62 percent. To put that into perspective, when multiplied by the total number of proposed implementations, over 8,500 labor hours were avoided – equating to more than four years of time.

“Support of the AAV Program was a unique opportunity to showcase the partnership between the USMC and Carderock and

“ **Support of the AAV Program was a unique opportunity to showcase the partnership between the USMC and Carderock and employ a new capability that was versatile and increased productivity.**”

Corrosion Service Team member Alberto Ramirez using the portable vacuum blast system as part of the Amphibious Assault Vehicle Common Remotely Operated Weapons Station Modification project in Camp Pendleton, Calif., in May 2021. (U.S. Navy photo provided by Eric Moffatt)

employ a new capability that was versatile and increased productivity,” Moffatt said.

The USMC CPAC program continues to look to effectively implement this technology into its repair processes both at the organization and intermediate maintenance activities. Carderock is currently leading an effort to outfit “on-the-lot” capabilities utilizing the portable vacuum blast system as part of a larger effort for enhanced surface preparation and touch up to help decrease corrosion repair backlog.

Carderock Collaborates with Warfare Centers on Digital Twin Prototype

By Todd A. Hurley, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center (NSWC), Carderock Division is part of a new collaboration that involves NSWC's Port Hueneme Division and Philadelphia Division, along with academia and several small businesses. The collaboration is a Naval Innovation, Science and Engineering (NISE) project.

The goal of the NISE project is to design, develop and demonstrate an autonomous, continuous monitoring system to analyze the health of Hull, Mechanical and Electrical (HM&E) systems aboard the Navy's Self Defense Test Ship (SDTS), which is stationed in Port Hueneme, California. The SDTS, formerly the USS Paul F. Foster (DD 964), has been repurposed to provide capability as

a laboratory in a realistic at-sea environment with the primary mission as being the world's largest test ship to operate in an unmanned and remote control mode for safe live-fire testing of ship defense systems.

A primary component of the project is the utilization of the SDTS to develop and demonstrate a Navy Digital Twin (NDT) Condition Based Maintenance (CBM) capability for the fleet.

"Through the application of these technologies, this project provides an opportunity for this Navy team to find ways to increase ship maintenance effectiveness by decreasing its downtime and get vessels ready for future missions more efficiently than before," Carlos

Boisselier said, a systems engineer in the SDTS Division at NSWC Port Hueneme Division.

The project duration is planned for three years, with the overarching goal to provide actionable information to decision makers via a prognostic health management system. Authorization for the system installation aboard the SDTS was granted in July 2021.

"We've been given three years to work on this project, but we hope to have it completed and to the fleet before then," Dr. Ben Grisso said, a mechanical engineer in Carderock's In-Service Ship Structures Branch, who has been working on developing methods to enhance structural hull health for over a decade.



The current system in place to analyze the health of certain submarine rotating and reciprocating machinery ships is to have Sailors walk around their ships with handheld analyzers that collect vibration data, which may then be sent for review by a subject matter expert. This new system will not only allow Sailors to return to their primary duties, but will also provide more frequent and accurate measurements.

“We don’t want to saddle our Sailors with duties that technology can accomplish,” Dr. Michael Robert said, the Technical Project Manager for NDT in Carderock’s Emergent Technology and Signature Analysis Branch. “The current methodologies also result in false positive measurements and information feedback time delays. What we are hoping to achieve will allow the process to be better and faster, with warfighters on the loop as opposed to in the loop.”

The impetus of the project is to ultimately outfit machinery and hull structures on submarines and carriers with sensors that can collect data and utilize machine learning algorithms to determine if the ship is running properly, or to detect and report – and eventually predict – any deviations from expected operational states.

“This equipment utilizes edge computing technology with the idea of computing extracted features, which allows us to collect data,” Sherwood Polter said, an electronics engineer and technical point of contact (TPOC) at NSWC Philadelphia Division. “This information we collect will lead us to a

likelihood of a failure mode. The more data we can collect, the better our models will be in the long run.”

NSWC Philadelphia Division’s role in this process is primarily to perform testing and collect data measurements to develop the proper algorithms for the system, as well as extract data for different failure modes.

Digital twins are a virtual representation of complex objects or systems, and as such can be used to predict future operational abilities of ships.

“Our systems will collect a plethora of data, which you can then use to train algorithms that will know whether it is good data or bad data, or trending in a certain direction” Robert said. “The smarter these algorithms become, the systems will begin to be able to make predictions of future HM&E performance.”

Robert, who is a principal investigator for this project, is also Carderock’s TPOC. He has been working with his team to write machine learning algorithms and in turn apply them to NDT CBM, aimed at performing maintenance only when the need arises.

“Essentially, with a ship, if you fix something before it needs to be fixed, then you have increased maintenance costs and decreased operational availability,” Robert said. “If you wait too long to fix things, then you damage the ship and increase maintenance costs, subsequently decreasing operational availability. What we are proposing is an idea to be able to accurately determine exactly when a ship needs to be maintained. NDT CBM tells you before you pull into port what is wrong and what needs to be fixed, which in turn increases operational availability of ships and decreases maintenance costs.”

The collaboration team scheduled to take their development to the SDTS in February 2022 to run tests and collect data to ensure everything works properly. They have developed and reviewed the technical drawing package and are completing cyber and wireless technology pre-installation testing requirements.

“Our overarching objective is to mature the technology levels of NDT CBM initiatives to have a prototype that is ready to be installed on unmanned undersea vehicles and submarines,” Robert said.

In order to achieve this objective, development and testing in an operational environment needs to be pursued, which is why they are in need of securing the SDTS.

“We have our initial algorithms written, but they need to be trained on SDTS operational data,” Robert said. “The SDTS is a test bed for the Navy to try out new technologies. While we are aboard the SDTS, we will collect operational data and monitor trends of those data. We can’t just put data measurement and collection systems – enable by machine learning algorithms on the SDTS and walk away — we need to characterize the operational environment for a week or more and then evolve the system over the course of a year or two.”

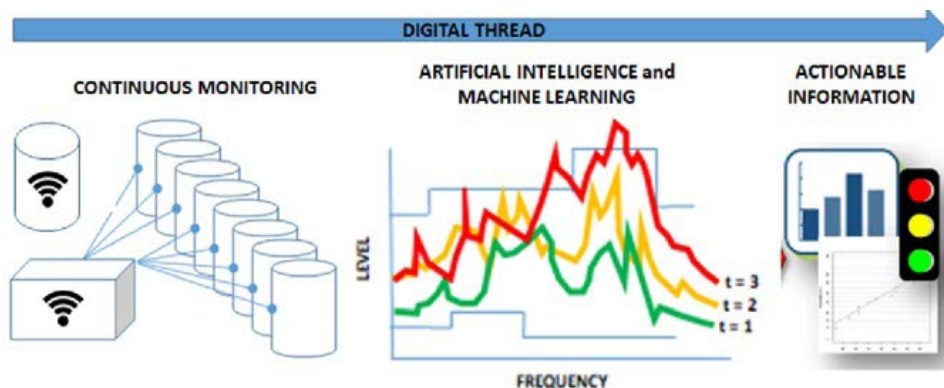
The project is not exclusive to the Navy — several small businesses and academia, such as Metis Design Corporation, Intelligent Fiber Optic Systems Corporation, Luna Technologies, KCF Technologies and Massachusetts Institute of Technology are also involved.

“Even before COVID, but especially since COVID, we wanted to ensure we included our small business partners,” Grisso said. “By having them help with the development process, it not only helps them stay in business, but also allots us more time to focus on the testing aspect of the technology.”

While the end goal is to get their product ready for the fleet, that does not necessarily mean it will be ready at the end of this three-year project.

“We are utilizing the SDTS for proof of concept purposes and would need to adapt and demonstrate the technologies on other fleet platforms before they could be operationalized for the warfighter,” Robert said.

The Navy’s Self Defense Test Ship, formerly the USS Paul F. Foster (DD 964), conducts a successful demonstration of shipboard alternative fuel use while underway in the Pacific Ocean, Nov. 17, 2011. (U.S. Navy photo)



A guide outlining the usage and steps of the autonomous, continuous monitoring system that will analyze the health of Hull, Mechanical and Electrical systems. (Graphic provided by Dr. Michael Robert)

Carderock Collaborates with NIWC PAC on NISE Project

By Todd A. Hurley, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division has collaborated with Naval Information Warfare Center Pacific (NIWC PAC) on a Naval Innovative Science and Engineering (NISE) project that took place in Carderock's Maneuvering and Seakeeping (MASK) Basin, which concluded in mid-September.

The collaborative NISE project between Carderock and NIWC PAC involves a slack tether management system that allows an unmanned aircraft system (UAS) to be able to operate indefinitely from an unmanned surface vehicle (USV) and reduces the parasitic load from the tether's tension. The tether provides power, data and control signal to the UAS to enable significantly extended operational time.

However, the tether introduces the challenge of tether management to prevent the tether

from fouling with the surface vehicle, or the tension from increasing too high and affecting the UAS. The coupled system was tested in the MASK to evaluate performance, collect data for model validation, and reduce risk for future at-sea testing. A new motion capture system recently installed in the MASK was used to measure the motions of the model in the water, the aircraft and of the tether.

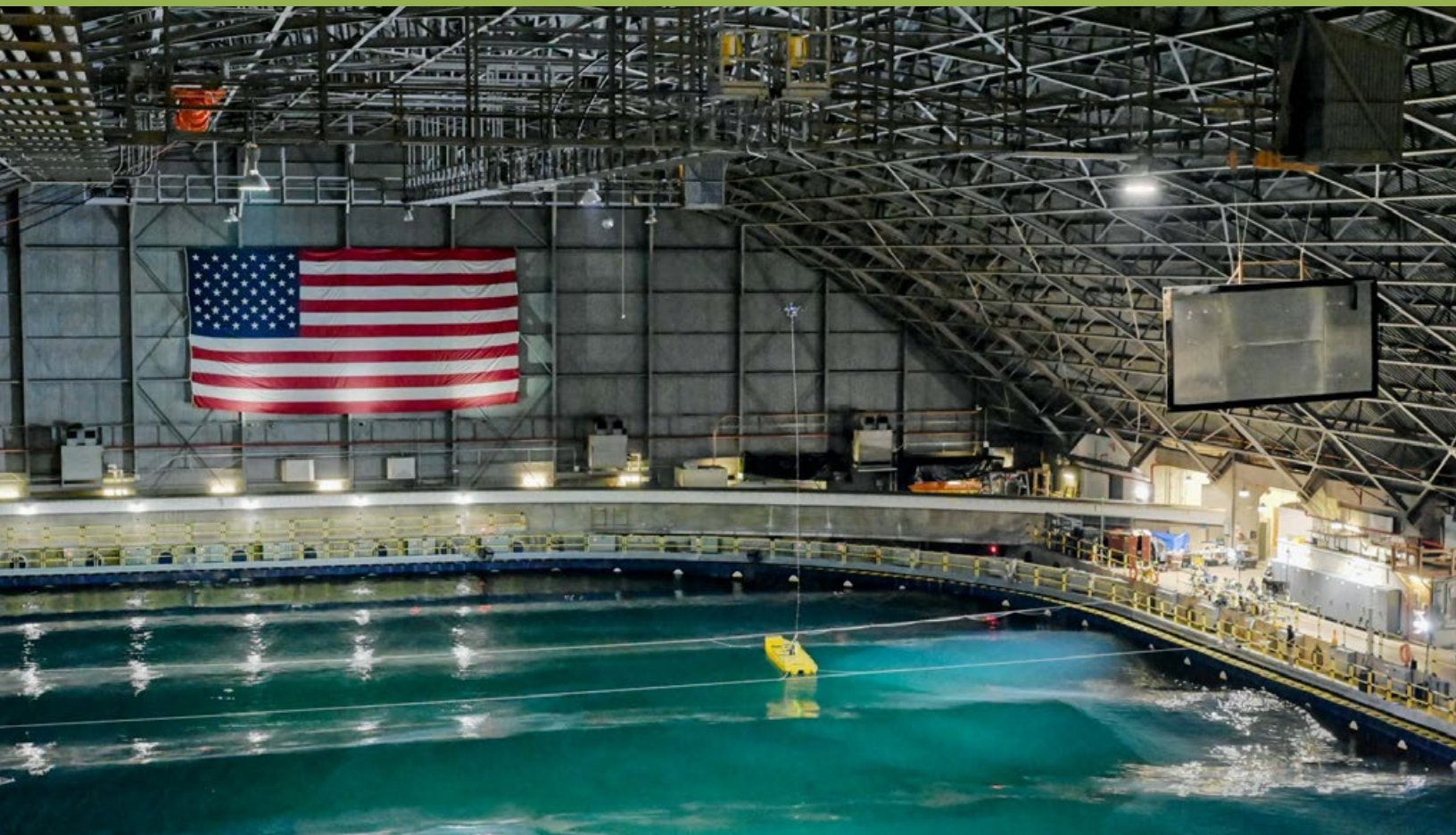
The initial concept stemmed from Dr. Kurt Talke, a mechanical engineer and the NIWC PAC lead on this NISE project, who got in contact with Dr. Jared Soltis, an aerospace engineer in Carderock's Sea-Based Aviation and Aeromechanics Branch, about using Carderock's MASK for the testing site.

"Six years ago I received a Science, Mathematics and Research for Transformation (SMART) scholarship to get my doctorate degree," Talke said. "Leveraging NISE funding, I was able

A 15-pound unmanned aircraft system being flown off a full-scale 20-foot unmanned surface vehicle surrogate in Carderock's Maneuvering and Seakeeping Basin while utilizing a slack tether management system, Sept. 17, 2021. (Photo provided by Dr. Jared Soltis).

to turn doctorate research into work research, which in turn led to this three-year project. At NIWC PAC, we built a custom mechanism to replicate boat motion in pitch, roll and heave, and performed initial testing. The next steps were to do wave testing for the prototype system I had built, so I got in touch with Carderock — Dr. Soltis, and we put in a proposal to receive matching funding from Carderock's NISE program to do the testing."





Carderock's role in the NISE project was to create a test plan, prepare a surrogate USV model, support system integration and lead test execution.

"The final week of the project consisted of performance evaluation and risk reduction testing," Soltis said. "NIWC PAC has been developing this system for a few years and they wanted to do more testing to prove it

Members from Naval Surface Warfare Center, Carderock Division and Naval Information Warfare Center Pacific pose in Carderock's Maneuvering and Seakeeping Basin on Sept. 17, 2021, while holding their 15-pound unmanned aircraft system, with their full-scale 20-foot unmanned surface vehicle in the background. From left, bottom row: Carderock members Kevin Mauck, Facilities Operations (Electrical) Branch, Dan Hayden, Seakeeping and Maneuvering Branch, and Anish Sydney and Dr. Jared Soltis, both of the Sea-Based Aviation and Aeromechanics Branch. From left, top row: NIWC PAC members Fred Birchmore, Nick Stroumtsos and Dr. Kurt Talke, the NIWC PAC lead on the NISE project. (Photo provided by Dr. Jared Soltis).

works, which is why they brought it to us so we could test it in the MASK. This will lead to an increase in fidelity and scale — the plan is to test it next year on a small fishing boat at NIWC PAC."

The overall goal is to prove the effectiveness of the tether system in order to provide a product to the Unmanned Marine Systems (PMS 406). The tether control methodology could transition directly to active programs within Navy Special Forces and PMS 406.

"These tethered elevated systems are of interest to multiple parts of the Navy," said Soltis. "They carry sensors aloft to have a further line of sight, as well as a farther line of communication. There has been growing interest to be able to fly a relatively small UAS off a relatively small USV, so that is exactly what we did with the testing. We used a full-scale 20-foot USV surrogate and a 15-pound aircraft."

The test in the MASK had two phases. Phase one was a risk reduction and system checkout phase in which a surrogate UAS was secured to the catwalk, and motion data was collected over a range of wave conditions. After the first series of cases, the control filter was updated, and the cases were rerun. In Phase two, the UAS carried the tether and the same wave conditions were run two more times.

"If you have a boat in waves and don't control the tether carefully, you could jerk the aircraft,"

Soltis said. "We need this tether management system to keep the aircraft safely aloft. Most commercial systems have constant tension, but that can lead to a loss in performance as you are constantly pulling down on the tether. Instead of controlling the tension, we are directly controlling the tether length. We have to calculate the optimal tether length to minimize the tension in the tether."

Now that the initial testing has been completed, Talke has taken the garnered data back to NIWC PAC to determine the system's effectiveness.

"We are going to take the lessons learned and look at the data to see if we can take this system out to sea," Talke said. "Our feedback is reliant on good estimates of relevant position. In the MASK we were able to obtain that with the motion capture system, but we are looking into non-GPS solutions. We want to leverage a simulation environment to create tether controllers that aren't reliant on relative position — there should be a way to control the tether length without knowing the exact position of the UAV, which is what we are working towards now."

This NISE collaboration will continue with a focus on wind loads on the tether and at-sea testing. Talke and his team will be back to test at the Carderock 8' by 10' Subsonic Wind Tunnel before conducting sea trials off the coast of San Diego.

Carderock's Stephenson Supports Software Installation at Trident Training Facility Bangor

By Edwin Hernandez, NSWC Carderock Division Public Affairs

It has been nearly two years since COVID-19 began to rapidly overwhelm the country's healthcare system, and with it normal business operations. Organizations like Trident Training Facility (TTF) Bangor have had to adjust to new working conditions; however, that has not stopped them from carrying out their responsibilities. TTF Bangor's mission is to train submarine crews to operate safely and prepare them to perform their missions at sea.

Steve Stephenson, a Naval Sea Systems Command (NAVSEA) Technical On-Site Agent for TTF Bangor, was recently recognized for his support in coordinating an on-site software upgrade installation on the Common Operational Analysis and Employment Trainer (COAET). Stephenson, an employee of Naval Surface Warfare Center, Carderock Division's Ship Signatures Department, significantly reduced the risk of infection or spread of COVID-19 to installation teams, TTF staff and submarine crewmembers, and his software installation was the first "in-house" installation of a Combat Systems Team Trainer (CSTT) upgrade.

With the pandemic restricting travel, Naval Surface Warfare Centers (NSWC) and Naval Undersea Warfare Centers (NUWC) installation teams were challenged to perform all the scheduled upgrades to the combat systems trainers across all the training sites. Discussing the problem with NAVSEA, Stephenson offered his team's services to install the 16.2 software upgrade in the COAET, which mitigated the need to have NSWC and NUWC installation team personnel onsite during the install. Although he was confident his team could perform the software upgrades to the trainer, Stephenson needed to coordinate the installation with the training command, prepare his Submarine Trainer Maintenance (SUBTM) Team and equipment for the installation, and ensure that he could support all other training requirements during the installation.

According to Stephenson, both NSWC and NUWC installation teams had a minimum amount of people to support four trainer upgrade installations at TTF. He added that the amount of boats being trained at the command could not have supported having both the Ship's Multi-Mission Team

Trainer and COAET down at the same time. Therefore, as Stephenson assisted in developing a mitigation plan to conduct the multiple installs with NAVSEA, he referenced the COAET TI 16, which had been successfully installed and fully tested at TTF Kings Bay by NUWC and NSWC installation teams. Stephenson asked NAVSEA to allow his SUBTM team to perform the install.

"In my tenure here, I have been in the building since 2003, I have never seen a major system upgrade conducted by the in-house contractor," he said. "It was a challenge I really wanted to take on. I knew that my guys had the skills, knowledge and capability to upgrade the system successfully."

After developing the installation plan in collaboration with NSWC and NUWC, NAVSEA agreed to have the Bangor SUBTM team install the software upgrade with Stephenson's coordination and oversight.

"We had two weeks to install the upgrade and thoroughly test the trainer before a ship's crew used the trainer for team training the following Monday; the trainer operated perfectly for training," he said. The build went smoother than I thought it would go – I was very pleased with that."

Then Acting Under Secretary of the Navy Adm. James Geurts presented Stephenson and his site lead Eric Somogyi with a coin for their accomplishment in installing the upgrade on the COAET. Stephenson, who is responsible for ensuring all training requirements are completed, oversees a variety of the command's operations. He is also a direct line of communication to the TTF Commanding



Sailors assigned to the Gold crew of the Ohio-class guided missile submarine USS Ohio (SSGN 726) practice driving a simulated submarine in the ship's control trainer at Trident Training Facility Bangor, Wash., on June 11, 2018. (U.S. Navy Photo by Mass Communication Specialist 1st Class Amanda R. Gray/Released)

INNOVATION AT WORK



Machinist's Mate (Weapons) 2nd Class Jalissa Thornton, assigned to the Blue crew of the Ohio-class guided missile submarine USS Michigan (SSGN 727), practices loading and firing torpedoes in the torpedo handling team trainer at Trident Training Facility Bangor, Wash., on June 21, 2018. (U.S. Navy Photo by Mass Communication Specialist 1st Class Amanda R. Gray/Released)

Officer Capt. Jeffery Smith.

"Here in the facility, I am the NAVSEA representative; I work directly for the captain and keep the command advised on the situations with their individual trainers," he said. "Whether that be the Combat Systems Team Trainers, Navigation Trainers, Ship's Control Operational Team Trainers or the various maintenance trainers."

The equipment at TTF Bangor plays an important role in the training and development of submarine crews and Sailors. Impressively, submarines crews can train in a safe, controlled environment using multiple team training devices to simulate operating a submarine in difficult or even dangerous situations. There are several advantages to this capability, but the most important is the safety of Sailors and submarines. According to Stephenson, the facility provides the perfect environment for submarine crews to perfect necessary combative and defense tactics.

"There are different wings in the building that provide different flavors of the submarine trade," he said. "The majority of our trainers are simulation-based in that we simulate very realistic tactical, geographical and environmental conditions for submarine crews to train. We can simulate putting a boat

anywhere in the world at any time of year, in any type of environment and sea-state, and we can simulate any type of contact that the boat would have reason to track or acknowledge while they are in scenario."

Stephenson's team also supports two full-motion trainers, which simulate the experience of controlling a submarine from inside a ship's control room.

"Full-motion trainers are cabs that sit on platforms and our software allows us to simulate environment, initial conditions, depth and ship motions," he said. "So when you are sitting in the cab, it's a completely enclosed except for a back observation window; all you see is what you would see in the control room. It pitches and rolls from side to side, just like an actual submarine would."

Additionally, TTF hosts eight maintenance labs that were built for submarine crews to practice their hardware and mechanical skills. The facility itself is 450,000 square feet and will soon transition its spaces for the new Columbia-class submarines. When Ohio-class training spaces become available due to trainer upgrades, or removal due to obsolescence, the vacant spaces will be reserved for Columbia-Class trainers. The Columbia class Manpower and Training Assessment Committee, which Stephenson is a part of, is developing the plan for the transition. Though most of the trainers will fit in the current facility, the building is being expanded to install a second Missile Control Center (MCC) to the east end and a Weapons Handling trainer and Ship's Control Operating Team Trainer to the West End. Stephenson will provide guidance for the future transition with his team, and will continue to oversee all training operations at the command.

*BANGOR, Wash. (June 21, 2018)
Electronics Technician (Navigation)
2nd Class Israel Orta, assigned to the
Gold crew of the Ohio-class ballistic
missile submarine USS Nebraska
(SSBN 739), looks through the periscope
in the attack center of Trident Training
Facility Bangor's Submarine Bridge
Trainer (SBT) in Bangor, Wash., on
June 21, 2018. (U.S. Navy Photo by
Mass Communication Specialist 1st
Class Amanda R. Gray/Released)*



Carderock Helps Research Mold and Mildew Outgrowth on U.S. Navy Ships

By Edwin Hernandez, NSWC Carderock Division Public Affairs

Fungus, mold and mildew growing in ship interiors can be a recipe for disaster. Not only can it affect a ship's coating performance, but it also presents a health hazard to Sailors. Three experts: Dr. Charles White, a chemist in Naval Surface Warfare Center, Carderock Division's Corrosion and Coatings Engineering Branch; Patrick Cassidy, a senior corrosion engineer for Elzly Technology; and Dr. Jason Lee, a materials engineer for Naval Research Laboratory South at Stennis Space Center, Mississippi, are using coating technology to control fungal growth.

Previous Department of Defense sponsored studies from the U.S. Air Force, Army and Marine Corps have outlined the damage mold and mildew can have on equipment infrastructure. Funded by the Environmental Security Technology Certification Program (ESTCP), Cassidy, Lee and White have launched a three-year research study project aiming to survey and identify fungal species growing aboard ships, identify the most effective mitigation strategies and evaluate inhibitive coatings to prevent growth and impact on Sailor's quality of life. In their research, they will also be monitoring coating degradation and corrosion.

"This is the first U.S. Navy study to holistically survey fungal growth across ship class and port location," White said.

When fungi begin to grow on coatings, they digest different resins, fillers and plasticizers. When that material is affected, the coating loses flexibility and is more vulnerable to cracking. This creates an entryway for water to seep into open spaces, leading to instances of corrosion.

An example of mold growing in an officer shower stall on a destroyer in 2020. In an enclosed wet space, the occurrence of fungi is common and difficult to prevent. Part of the study will evaluate whether fungal growth leads to corrosion. (U.S. Navy photo by Dr. Charles White)

"It's a reinforcing cycle," White said. "Mold growth can lead to respiratory issues and coating degradation. Once the coating is compromised or performance reduced, corrosion can occur. When the coating is removed, the waste is contaminated with fungi that can be hazardous or that has to be disposed in a specific manner to avoid an environmental impact. By reducing the rate of fungal growth to extend the life of coatings, there is a reduced cost and maintenance burden to the fleet and reduced impact of ship's force health."

Cassidy, Lee and White have collected samples from various ships across all the corrosion repair centers in the United States in order to understand fungal growth before treating it. Their plan is to document which fungal species are growing, on what surfaces and spaces and at what frequency and severity. In addition, identify any fungal species that poses a health risk to service members.

"This is a highly collaborative effort among the three facilities," White said of the partnership with Lee and Cassidy's organizations. "I am very excited to work with Jason and Pat to provide a solution to this issue."

The collaborative effort received funding

An example of mold growing on a cruiser in Norfolk in 2020. This is bulkhead exposed to continuous condensation. (U.S. Navy photo by Dr. Charles White)

from ESTCP in early 2021. ESTCP is the Department of Defense's (DOD's) environmental technology demonstration and validation program. ESTCP was established in 1995 to evaluate and transfer innovative technologies that reduce the environmental impact of DOD systems. After receiving funding, Cassidy coordinated visits for sample collections with his team at various naval installations. The samples have since been collected from different naval and commercial ship yard facilities. In addition, sample swabs were sent to other facilities for local waterfront personnel to take swabs, such as in Pearl Harbor in Hawaii.

"Fungi are very easy to grow," Lee said. "We grow them on culture plates – if you take a swab of the fungi and put it on the plate it completely takes over. Fungi grow in different stages, they have an active stage and

Continued on next page







An example of mold growing on the overhead passageway on an amphibious assault ship in Norfolk in 2020. The passageway leads to an exterior area and is exposed to salt spray, air overturn, fumes and more. (U.S. Navy photo by Dr. Charles White)

Continuation from previous page

a dormant stage. Generally, in their active stage, filamentous fungi resemble finger-like bodies; in their dormant stage, they are spores, and that's what we see visually in day-to-day life. Once we flood the plate, those spores will detach and go into a suspension. Then we can load the suspension in an air-sprayer and spray it on the coating samples we want to test."

After the coating samples were sprayed with the fungus, Lee said the sample panels went into a humidity chamber. From there, Lee could control the temperature, the humidity – which is the most important for fungi because "it likes wet, high humidity spaces," according to Lee – and it is dark. He periodically took the panels out and photographed the growth for record keeping.

"We will also want to identify the fungi by using molecular DNA or RNA techniques – giving us an idea of what's there," Lee said. "Different fungi can produce different metabolites like acids and enzymes that can attack coatings differently. In the laboratory, we will assess the damage, observe the growth, see what's growing and how much of it is growing."

Although only at the end of the first year of the three-year project, White said he will be preparing experimental panels that replicate problematic areas on ships for testing. This includes coated samples and laboratory testing on fungal-aged coatings. Together, the team is hoping to find active ingredients in coatings that discourage growth and kill spores tailored specific to the fungal identified in the ship survey. If successful, the team will prepare for a shipboard demonstration.

"When we have something ready, I will coordinate with our site representatives to choose a space aboard the ship to apply the coating," Cassidy said. "Then we will see how it performs over time against the fungi."

Some of the high-risk areas aboard a ship include overhead spaces and passageways that accumulate salt-water spray, air from outside, or even exhaust from engines.

"There are certain conditions that lead to fungal growth," White said. "High humidity areas like laundry rooms on ships or where there is not a lot of air turnover are particularly prone. Fungal spores are everywhere; they can travel on the fumes that come in from air turnover from the outside environment and other passageways."

Recently the Navy has performed a massive cleaning effort because of COVID-19, decontaminating surfaces in an effort to limit the spread. White has said that he and his team will be taking lessons learned from that operation and applying it to their own research.

While this study is focused primarily on fungi, White is hoping that his team's research will raise awareness for microorganism surveys and the potential for virus control. Cassidy, Lee and White will be testing several cleaners too, to see which are most effective in removing mold and killing spores.

One cleaning supply that is a common household item, bleach, can be an ineffective cleaner for fungi. According to previous research conducted by Lee, bleach can contribute to fungal spread and give spores access to deeper cracks and crevices.

"There has been high interest from the fleet and from manufacturers for the development of fungal inhibitive coatings," White said. "We are developing a non-disclosure agreement with paint manufacturers to develop and test fungal inhibitive coatings."

Due to interest from the technical community, Lee and White have presented the project at the other DOD cross-service organizations.

"These cross-service organizations host a call for proposals for fungal mitigation and was interested in leveraging the results of our project and biodiversity survey," White said.

The project team is currently in the process of identifying fungal species through DNA analysis.

"We have prepared samples of coatings for technical evaluation and laboratory testing," White said. "Once we have the biodiversity report, we will submit for public release to share with technical community and allow for representative laboratory testing."

The plan is to have the DNA analysis by arch 2022, and to then have it available for public distribution.

"We have received a lot of interest from government and academia," White said. "Once we get the results, we can recommend the species used in lab for more representative testing to see what is actually growing on what. The results will help us to learn if there are any high risk or specific health impacts fungal growth can have on Sailors."

Once they receive their results, the next step will be to do a ship demonstration by the fall of 2022. They plan to use novel cleaners to disinfect the surface without having to repaint, and to strip paint off of problem areas to do a large patch of inhibited coating.

"The fungal growth can grow back frequently with some reports indicating that fungus can grow within a week after it is cleaned sometimes worse than before cleaning," White said. "So we should be able to tell pretty quickly if inhibited coating is preventing the fungal growth or not."

Carderock Engineers Test New Oily Water Separator System

By Edwin Hernandez, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division engineers are testing a new centrifugal system to separate oily wastewater aboard naval ships. The project, directed by Carderock's Environmental Engineering, Science and Technology Branch, is sponsored by NAVSEA 05PF and is focused on two primary aspects: performance and reliability.

"One issue with the current oil/water separator (OWS) is that it requires a lot of maintenance," Adam Grossman said, an engineer in Carderock's Environmental Engineering, Science and Technology Branch said. "What we found through our laboratory evaluation is – although every system is going to require some upkeep – this new system comparably, did better. It was very reliable. We operated it for about 1,100 hours and there was nothing outside of regular maintenance that we needed to do to the system."

The centrifugal system was first tested at Carderock's Wastewater Laboratory in 2015, and maintains a respectable reputation for its ability to separate liquids containing different densities.

So, how exactly does it work, one might ask.

The centrifugal system utilizes a quick spinning bowl to generate force to exploit the density differences between oil and water and separate the two. After oil and other contaminants have been separated from the wastewater, it can be safely discharged into the ocean.

The centrifugal system's earlier designs were installed on several MSC ships and received positive feedback, which in-turn, inspired the current project. While centrifugal systems are nothing new, and although Grossman has had modest success with these types of systems in the past, he said the current system being evaluated and developed is different and produced better results.

"We fed the system various test fluids that simulate oily wastewater conditions aboard a ship," Grossman said. "There's a lot of chemically emulsified oil, which occurs when detergents or other surfactants cause oil droplets to disperse through your water matrix – and then it becomes harder to separate. The new system was able to process water with chemically emulsified oil down to regulatory limits, consistently."

Now, six and a half years into the project, Grossman and his team have recently completed the first phase of the shipboard evaluation aboard USS Lassen (DDG 82).

"The shipboard evaluation has been a

tremendous success so far and we are continuing to evaluate longer term performance and maintenance needs of the OWS," Grossman said. "We have been able to get high quality data that demonstrated this system could consistently and reliably treat oily waste to regulatory limits for safe overboard discharge. DDG 82 ship's force have been thrilled with the system's performance and ship's command is in the process of submitting a nomination for an Environment Protection Award."

Grossman also noted that, "This is just one example of the benefit of research that starts at Carderock's Wastewater Laboratory and that can be provided to the Fleet. Various systems and system components used to manage a variety of waste streams can be evaluated with our tools and expertise. This in-turn will provide critical support to a wide range of shipboard activities and operations."

Based on the results of the shipboard evaluation so far, OWS has shown the potential for Fleet-wide impact for forward-fit on new acquisition platforms, as well as back-fit on select DDG 51 class ships.

The most rewarding part of the job is providing benefit to the fleet and the environment, as well as receiving positive feedback for the work we are doing," Grossman said. "We want to help our Sailors and reduce the burden on them, and this system was able to do just that."

The influent sample (left) is a chemical emulsion with an oil concentration of 1,000 parts per million (ppm). The midpoint sample (middle) is effluent directly from the centrifuge outlet. The effluent sample (right) is from the outlet of the polishing filter. All samples were collected during Sea Trials in the summer 2021. (U.S. Navy photo by Adam Grossman)



New Scanning and Inspection Method for Submarine, Ship Propulsion Shafts Saves Time and Money

By Todd A. Hurley, NSWCC Carderock Division Public Affairs



The Shaft Taper Analysis Verification Evaluation (STAVE) system is a digital scanning technology and inspection process, which was developed to replace the plug and ring gauge system submarines, nuclear aircraft carriers

and other ship classes with fixed-pitch propulsion shaft taper refurbishment, aligning with NAVSEA's strategic framework in transforming digital capability.

The project goal for STAVE was for it to be

authorized on all submarine propulsion shaft repairs and refits, to reduce the shaft repair manpower requirements, as well as reducing the cost of shaft tooling and to increase consistency and quality of shaft tapers. This aligns directly with Naval Surface Warfare

Center, Carderock Division's strategic plan under the platform integrity and performance pillar of sustainment-based technologies. STAVE is easy to implement and maintain and creates a digital record of the shaft during construction and repairs, all while eliminating contact percentage variability between machinists.

"Taper gauges are used to inspect shaft tapers when getting repaired," Anthony Brock said, 3D Measurement Lead Engineer in Carderock's Performance Evaluation Branch. "But they are expensive to build and maintain. A lot of rigging is required to lift the gauges, which are roughly 2,000 pounds. We came up with an idea to develop a solution to replace these gauges since they are heavy, cumbersome and involve massive logistic issues."

A projector provides visual feedback of the STAVE System measurement onto a portion of a shaft. (U.S. Navy photo by Anthony Brock)

The idea is saving the Navy money. A STAVE system unit can inspect all submarine classes and nuclear aircraft carriers at a shipyard; subsequently, the Navy's is no longer purchasing new gages for shaft refurbishment. The implementation of STAVE also will eliminate the costs for periodic refurbishment and logistics associated with shipping gauges between facilities.

The STAVE System also saves time. It does not require the removal of the tail stock for measurements on lathe, nor does it require

The scanner and a shaft with just the tapered end for testing with the Shaft Taper Analysis Verification Evaluation (STAVE) System. This shaft was decommissioned and cut down to manageable size for testing. (U.S. Navy photo by Anthony Brock)

rigger support to set up and use. This frees the riggers for other critical jobs and allows the shafting shop to perform inspections on any shaft, even on short notice.

This system, which has been in development at Carderock for nearly 13 years and is led by the Structures and Composites Division, has finally been put into the fleet. Brock



presented the STAVE system at the virtual NAVSEA Industrial Innovation Partnership Day on Dec. 8, 2020.

This project originally started in 2008 as a cumbersome work practice by former Carderock employee, Alan Cohn.

"At the time, I was tasked with investigating the use of a laser tracker as a means of performing shaft measurements without using gauges," Cohn said. "After some early experimentation, it was determined that a laser tracker would not provide the necessary resolution or accuracy to capture the minute

surface defects that would affect contact with the coupling sleeve. I continued to investigate other technologies including Photogrammetry and Structured Light. It was determined that structured light was the only technology capable of the resolution and accuracy needed for the contact mapping."

The current iteration of the project has been led by Brock since 2016, with Amy Moore and Lyshawn Dean (SEA04T), Quoc B. Nguyen and Dave Lytkowski (SEA05Z), Jose Bernardo (PTI) and Mike Agronin (Direct Dimensions

Continued on next page



A projector is used as an accessory to the STAVE System to provide visual feedback of the measurement onto the shaft. (U.S. Navy photo by Anthony Brock)

proper accuracy, while Bernardo's employer designed the software to put the measurements together.

"The technology simply wasn't there when we first started this process," Brock said. "But, in the last six or so years, 3D scanners have gotten to a point where they are good enough to measure large areas with extreme accuracy."

Since developing STAVE, Brock and his team have been in contact with the four major naval shipyards – Norfolk, Pearl Harbor, Puget Sound and Portsmouth – in order to get their system to the fleet. So far, they have been able to get STAVE delivered to Norfolk and Portsmouth, with the next step being to deliver it to Pearl Harbor and Puget Sound.

"We received tremendous support from all the shipyards," Brock said. "One reason STAVE turned out so well is that the concept had so many false starts before this point. That really encouraged us to take a more customer-driven approach, which led to us visiting all of the shipyards more than once. We took our equipment to each of the shipyards to not only interact with them and show them how the system worked and how it was evolving, but also to show that we weren't hiding anything – we wanted them to be there with us to contribute their concerns and ideas. If we didn't go to the shipyards, we wouldn't have noticed simple changes that could completely change the accuracy of the system."

With the success of STAVE, Brock and his team have since discussed a Rudder Analysis Verification Evaluation (RAVE) tool concept.

RAVE will be a digital scanning technology and inspection process developed to replace the piece-by-piece blue-hit inspection for nuclear-powered aircraft carrier steering rudder stock tapers and submarine rudder stock and diving stock tapers.

The goal of RAVE is to have it authorized for use as an inspection tool on rudder repairs and refits; to reduce the rudder repair manpower requirements; and, to increase the consistency and quality of data for rudder tapers. The RAVE project is set to begin as soon as funding is available.

Continuation from previous page

Inc.) joining at various times over the years.

"We had a white-light scanner with a smaller field of view," Bernardo said. "It was a good piece of equipment, but struggled to do anything aside from scanning a taper, and only had a 33 percent chance of success. We decided we wanted to design a better process,

which is what we did with the digital scanner. It was a gigantic improvement and started solving a lot of our issues with better accuracy and more smoothness to data – it took the process from hours to about 12 minutes."

Agronin's employer, Direct Dimension's Inc., was responsible for coming up with the hardware to measure large surface area with

Marine Corps DC Power Distribution System

By Todd A. Hurley, NSWC Carderock Division Public Affairs

Evan Rule, a power systems engineer in Naval Surface Warfare Center, Carderock Division's Expeditionary and Developmental Power and Energy Branch, recently pitched a concept to the U.S. Marine Corps to help resolve a materiel gap related to distributing power to direct current (DC) equipment.

"Current Marine Corps DC power solutions are cumbersome and undergo wasteful and unnecessary power conversion," Rule said. "Marines lack a streamlined, easy-to-use means of distributing power to their most forward-deployed capability sets. For this reason, we came up with this concept."

Rule's concept is an internally developed DC power distribution system. This will provide warfighters with an intuitive materiel solution that will enable them to distribute power between existing and future DC sources and loads with minimal required training.

"It is a very simple solution," Rule said. "You can envision it to be a DC power strip."

The DC power distribution concept will consist of a power distribution box, NATO standard cables, a daisy-chain cable to expand capacity and mil-standard connectors that will allow compatibility with current and future equipment with little or no modification.

Rule conducted a two-day user workshop with the II Marine Expeditionary Force at Camp Lejeune, North Carolina, who is looking for solutions to reduce their footprint and become more operationally effective. During the workshop the Marines were briefed on the benefits of this new concept



and adoption challenges were worked through with several Military Occupational Specialties (MOS) representing various Ground Combat Element (GCE) units.

His DC power distribution concept is intended to support mobile capability sets as the Marine Corps transitions to a new fighting doctrine.

"Over the last decade we have been working with the Marine Corps' Expeditionary Energy Office and going out into the field to try and track their power and energy usage," Rule said. "In the last two years the Marine Corps has been pushing to be more mobile, so we've been focusing on capabilities that enable the Marine Corps' new mobile fighting construct. It became apparent to us that they didn't have a great program of record solution to distribute power to their equipment, which was causing a lot of issues."

It soon became abundantly clear to Rule and his team that the Marine Corps was having to purchase power supplies off the internet, some going as far as buying devices to plug into cigarette lighters in order to power their equipment.

"What seems to be part of the issue is that the acquisition community is somewhat isolated from themselves and from the end users," Rule said. "The result is a disjointed family of systems coupled with unique and constantly

A direct current (DC) power distribution system, conceptualized by Carderock employee Evan Rule, a power systems engineer in the Expeditionary and Developmental Power and Energy Branch. (U.S. Navy photo by Evan Rule)

evolving user needs. So what we saw is that Marines were coming up with creative, but costly and inefficient, ways to power their DC loads. We decided we needed to standardize the interface between the power sources and the load across the board."

Rule and his team were able to get funding from the National Defense Center for Energy and Environment (NDCEE), as well as Marine Corps Systems Command to pursue their concept.

"We figured we could provide them something very quickly and inexpensively to solve this problem," he said. "So we went out and got funding from NDCEE, as well as the Marine Corps Systems Command to develop the prototype."

Rule's concept claims to be abundantly beneficial.

"This concept increases reliability and operational effectiveness because it requires no fragile or expensive power electronics, has fewer components and fewer connection points," Rule said. "It also increases electrical efficiency which will help to increase operational reach and forward sustainment. It is also much more cost effective. There is an initial cost difference of about \$100k per battalion. The cost benefit will increase overtime."

Rule is currently working with the Marines at Camp Lejeune to help integrate his concept into some of their existing capability sets.

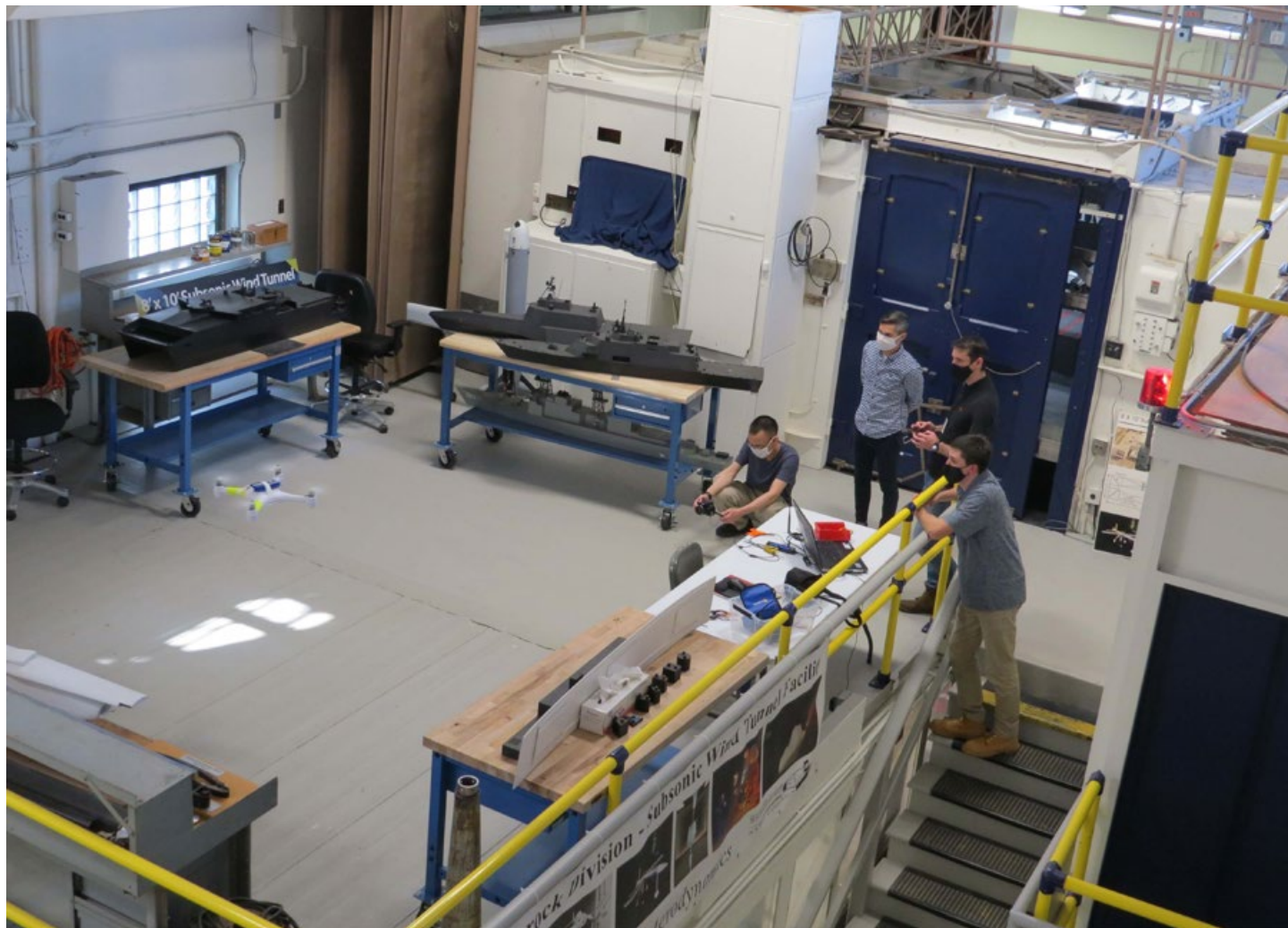
"It is ready – we have working prototypes now," Rule said.

The DC power distribution system consists of a power distribution box, NATO standard cables, a daisy-chain cable, an installation tool, cable connectors, assorted connector contacts and installation instructions. (U.S. Navy photo by Evan Rule)



Carderock's UAS Lab Performs Flight Tests on Prototypes

By Edwin Hernandez, NSWC Carderock Division Public Affairs



The Unmanned Aerial Systems (UAS) laboratory at Naval Surface Warfare Center, Carderock Division was established in 2018. Since then, Eric Silberg, an Aerospace Engineer in Carderock's Sea-Based Aviation and Aeromechanics Branch has been championing and expanding the lab's capabilities with the help of his team. Members of the UAS lab recently conducted a number of UAS flight test events at the command's Tridelphia Reservoir facility, Olney Support Center and high bay in Building 7.

"The testing we did in Building 7 and at Olney is definitely geared to the smaller end of the spectrum of the things we do," Silberg said. "We are looking at building different kinds of capabilities to do a variety of missions. Last week, we flew in the Building 7 high bay for the first time. That event was a check flight for an aircraft we are using for development of a new hybrid battery concept – which our colleagues in Code 60 are working on. The flight characterized the power needed for the small drone to fly by analyzing data collected on board the aircraft during the test."

This flight was a milestone first in Building 7. The building was the former home of the Aviation Department and is now the new home of the Sea-Based Aviation and Aeromechanics Branch. Silberg is planning to expand the UAS lab's capabilities in the space, collocated with the Subsonic Wind Tunnel. These plans include adding a motion tracking flight arena, propulsor testing lab and conducting flight testing inside the wind tunnel – in addition to design and construction of UAS.



This is not the first time Silberg and his team have used Carderock's facilities for flight testing in a controlled environment. In the past, small multi-rotors and seaplanes have been flown in the Maneuvering and Seakeeping Basin (MASK), and seaplanes have been flown in the David Taylor Model Basin. Silberg is looking forward to expanding the use Carderock's world class hydrodynamic facilities for a variety of UAS testing.

From left to right: Carderock Engineers Kevin Lin and James Mulford with the Expeditionary and Developmental Power and Energy Division, along with Eric Silberg and Robert Brown of Carderock's Sea-Based Aviation and Aeromechanics Branch, fly a drone inside the high bay of building seven on Feb. 24, 2021. (U.S. Navy photo by David Haas)

The UAS team selects specific locations for their testing citing the importance of the test environment for each system, and for the type of experiment that will be conducted. Some tests may need rough seas, others may require calm water and still air – and even then, it is possible the Lab may need an environment prepared for a particular sensor. Federal Aviation Administration rules and Navy regulations must also be taken into account while planning flight operations. Luckily for the UAS lab, Carderock's facilities provide many options.

Robert Brown, an engineer in Carderock's Sea-Based Aviation and Aeromechanics Branch, is leading the effort to design and build the seaplanes that are being tested at Carderock's Olney Support Center and the Tridelphia Reservoir. These UAS' are designed to be expendable and need to be simple and inexpensive to manufacture.

To that end, many parts of the seaplanes are made by the Additive Manufacturing Lab, including foam parts from 3D printed molds. This method of producing aircraft allows the team to make design changes quickly and eventually to build aircraft in relatively large numbers at low cost. Silberg and his team showcased their seaplanes at the 2021 Advanced Naval Technology Exercise (ANTX) in Camp Lejeune, North Carolina.

"We are going to be bringing these systems out to ANTX and fly out over the beach," Silberg said, who is looking forward to flight testing from the ocean and protected waterways. "We'll be experimenting with aircraft performance capabilities, and how it can be used in that kind of maritime environment."

Although the UAS lab is still relatively new, multiple projects have contributed to the design and advancements of new systems. One of those is the Magnetic Anomaly Detection (MAD) UAV, a Naval Innovative Science and Engineering (NISE) project led by Matthew Raphaely of Carderock's Research and Technology Development Branch, which was the UAS that was featured at the ANTX.

While at the Olney Support Center, Silberg

Engineers Avery Gaxha of Carderock's Sea-Based Aviation and Aeromechanics Branch and Matthew Raphaely of Carderock's Research and Technology Development Branch prepping an aircraft and sensor for a flight test. (U.S. Navy photo by David Haas)

used an onboard flight control system and a manual controller to pilot the aircraft. Though the seaplanes were airborne for some time, they encountered 14-15 mph winds and were grounded shortly after. The team was nevertheless able to test performance of the aircraft and collected valuable data for the MAD sensor.

"Now we're taking everything we learned from these test flights and making modifications needed to the aircraft to address performance," Silberg said. "We'll start integrating the more advanced capabilities into these systems. For example, we'll be developing some autonomy for them to operate on the water by sensing waves."

Carderock's UAS lab is also involved in several projects with other organizations.

"We have a growing portfolio of projects ranging from NISE Research and Development efforts, to supporting acquisition. Everything from designing and building small aircraft ourselves, to larger systems that are a part of the design of UAS to be deployed in the future."

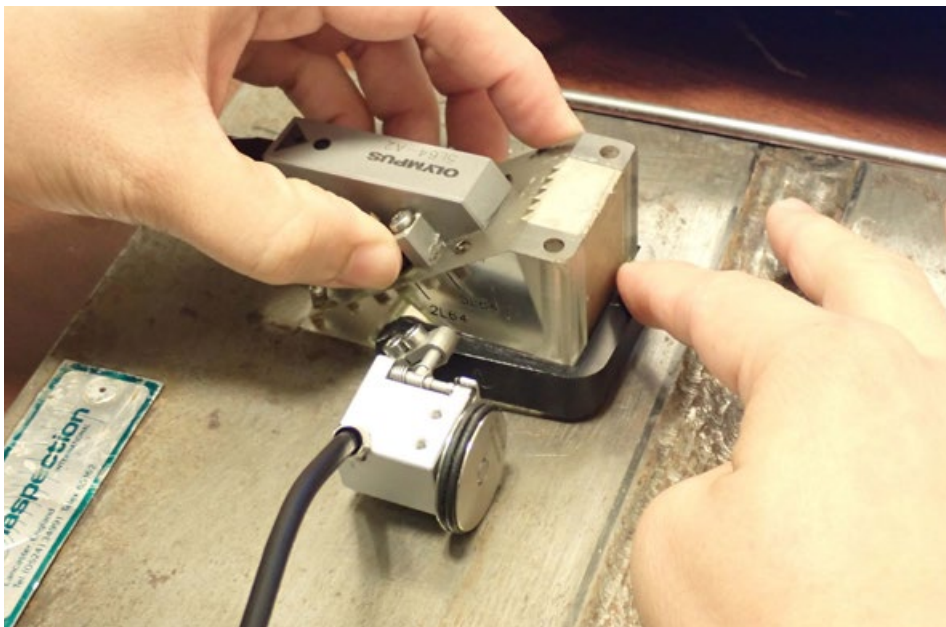
Aside from participating in ANTX, the UAS lab is also working on an Anti-Submarine Warfare vector sensor UAS with Naval Undersea Warfare Center, Keyport Division. Silberg said the objective of this collaborative NISE project between Warfare Centers is to integrate a small, lightweight vector sensor into UAS' to build a self-deployable and mobile sonar system.

"Currently, we have plans to go out to Keyport in the May timeframe to do our initial integration and flight testing," he said. "Assuming everything is successful we'll move on to the next stages of that project."

As a new lab, Silberg said it has been a challenge to find the right spaces to achieve their technical goals. He added that the lab's priority is to build capabilities for UAS research and development, and to support Carderock projects that would benefit from using drones. Keep an eye out for Carderock's UAS lab, they're proving to be a priceless commodity.

3D Printing the Little Things

By Todd A. Hurley, NSWC Carderock Division Public Affairs



Dr. Charles Nguyen, an engineer in Carderock's Welding, Processing and Nondestructive Evaluation Branch, using a 3D printed clamp (black part) in Carderock's Manufacturing, Knowledge and Education (MAKE) Lab on July 6, 2021. This piece holds an encoder onto an ultrasonic transducer wedge for weld inspections. This part normally costs \$5000, but can be printed in less than an hour in Carderock's MAKE Lab and costs fewer than \$10 in material. (U.S. Navy photo by Scott Ziv)

In the world of additive manufacturing (AM), or, more commonly referred to as 3D printing, people are always wanting to transcend what has been done before – to make the next thing flashier and larger than what was previously printed. However, there are tons of little, seemingly insignificant things that can be printed that make a considerable impact.

Naval Surface Warfare Center, Carderock Division's Manufacturing, Knowledge and Education (MAKE) Lab is an excellent source to learn about the AM process and its application to the Navy.

"The purpose of Carderock's MAKE Lab is to educate people on how to effectively use AM and give them access to the technology," Scott Ziv said, a mechanical engineer in Carderock's Additive Manufacturing Branch.

Carderock's MAKE Lab was conceived in 2016 as a base-wide makerspace, and has been used for various projects over the years.

"We keep watching AM across the board in the Navy, and most of the attention is placed very heavily on using AM to make end-use parts for the fleet," Ziv said. "Which, granted, is what we are here for. But there's also a whole world of untold stories using AM as a tool to accelerate the development of new products or just make us more efficient and organized."

While the MAKE Lab dabbles in large, vastly

important 3D printed technology, it also provides a significant number of smaller items that are easy to overlook.

"We've been involved in printing microelectronics cases, molds for potting cables, front-leading edges for mounting sensors, vacuum forming molds, cases for soldering irons, holders for gauges, bookends, standoffs for control boards and boxes for organization," Ziv said.

While there have been several large-scale items that have been created in the MAKE Lab that have saved considerable time and money — including the printing of developmental turbine blades that saved the Navy approximately half a million dollars — Ziv would like for the lesser-known capabilities of 3D printing be recognized more frequently, as well.

"We want to find a way to use AM for not only big things, but also for smaller things. Some things may seem unimportant, but are very helpful – like door stops," Ziv said. "People think of additive manufacturing as having a big overhead cost, but realistically, if it's an off-the-shelf thing, you can just go on the internet and download whatever you want and hit print, which for some commonly needed things is far faster than standard procurement and most times is also cheaper. There's a website called 'Thingiverse' that has millions of pre-designed models for everything from doorstops to tool organizers, to wall

mounts, tape holder and radius gauges. It's a great logistics tool for all those very niche, little plastic bits we engineers use every day."

Zachary (Zak) Kaler, an engineer in the Propulsor Acoustics Branch, who spearheaded the printing of the turbine blades, has also been 3D printing shrouds for a test rig and using those printed parts to support experiments in the Anechoic Flow Facility (AFF).

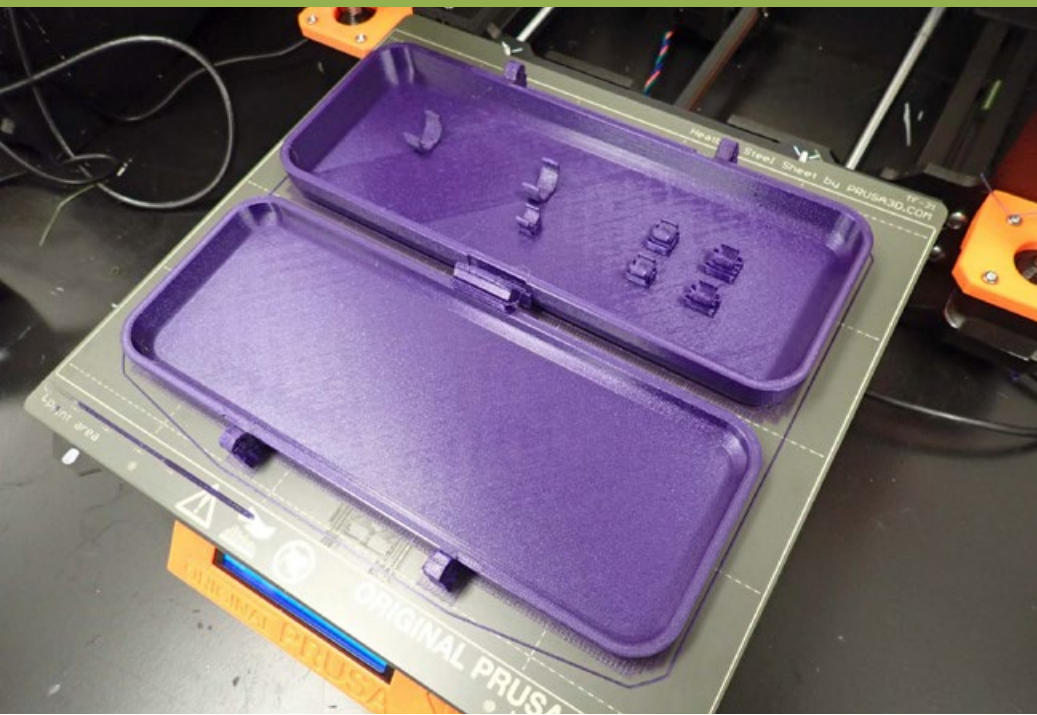
"One of our experiments involved the testing of an aluminum rotor, and we wanted to look at a number of geometric variations of the original rotor," Kaler said. "3D printing allowed us to quickly create several variations of the original rotor at a significantly lower cost than the original aluminum. We also used 3D printing to manufacture fairings which cover structural components in the flow. This opens up possibilities for the design of the test stand because it allows to easily and quickly create aerodynamically streamlined shapes."

By using the MAKE Lab to 3D print this technology, Kaler is able to save considerable time.

"It is very impressive how quickly they can turn these parts around," he said. "We got one a few weeks ago that was more complex than others, but it was only a week before we got it back from the MAKE Lab. It is great for if a problem arises that we didn't expect and a new part is needed – delays can be prevented because we can get a part in days — verses months for traditional manufacturing."

Another important item that Carderock has 3D printed in the last couple years is a sleeve that fits the outer contours of projectiles. This concept came about while the Hull Response

INNOVATION AT WORK



A purple, 3D printed case used to store a TS100 soldering iron and spare tips, created in Carderock's MAKE Lab. (U.S. Navy photo by Scott Ziv)

and Protection Branch were attempting to capture all relevant physics associated with the impact and penetration of bullets and fragments. Data collected included projectile velocity as well as its pitch and yaw.

“As all the test specimens were fired out of a rifle barrel, they spun when travelling down range,” Eric Walzer said, an engineer in Carderock’s Hull Response and Protection Branch. “We wanted to measure this spin rate in the tests. To do so, we needed to have markings on the projectiles so that we could watch the rotations of the markings in high-speed video of the test event to calculate the spin rate.”

Drawing the fiducial markings – reference points to measure data – on the projectiles proved too challenging due to them having a curved surface. Therefore, Walzer and his team decided to print the sleeves.

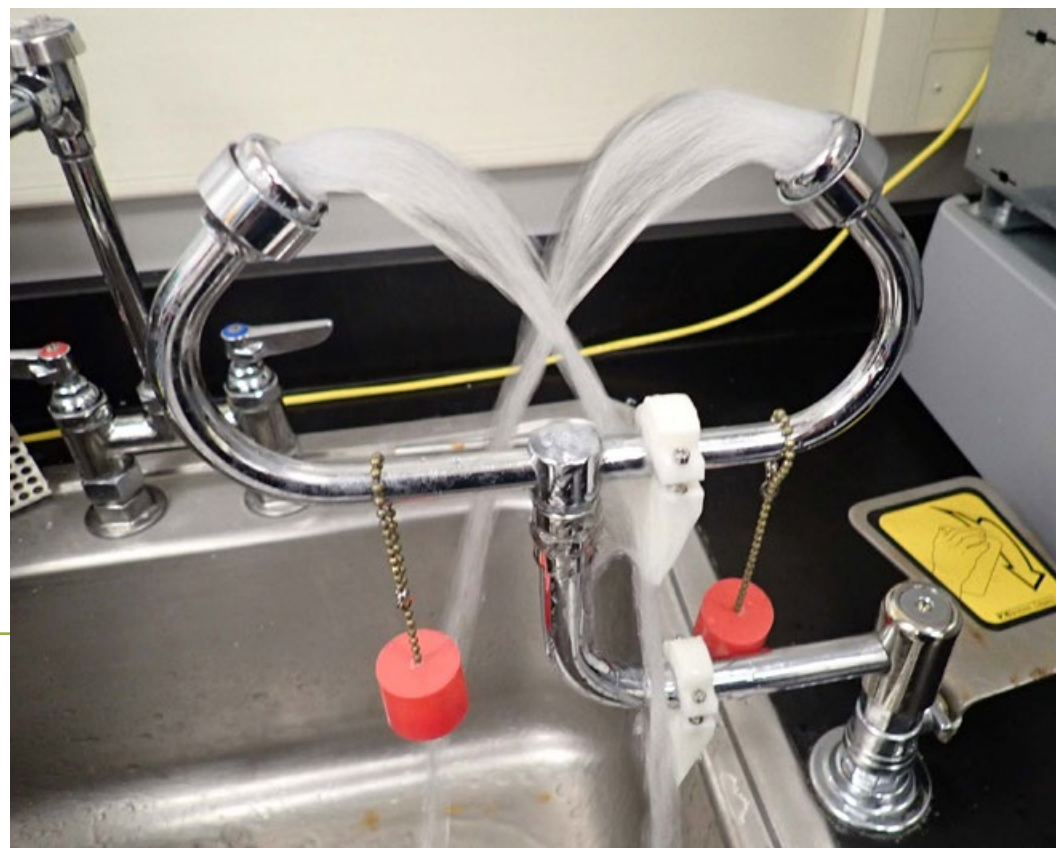
“In these sleeves we created evenly spaced slits that were arrayed in 45-degree increments around the projectile,” Walzer said. “This allowed us to draw the lines on the projectiles in the exact 45-degree increments we were looking for, which allowed us to capture the data. This was particularly important for projectiles that have complex curvature ... with the sleeves we could 3D print any sleeve shape we needed to in order to draw the lines.”

Walzer and his team have since submitted a patent application for the sleeves and were authorized to file a patent application for “Device for Drawing Fiducial Markings on Projectiles for Ballistic Testing,” Case No. 112, 518.

With the rapid updates and changes to AM on a regular basis, Ziv would like for the MAKE Lab to be used as a learning center to help people better understand AM and to keep up with the ever- growing changes. The MAKE Lab is currently working on relocating to share a facility with the larger traditional manufacturing shop on base to better bring traditional and additive equipment together.

“The underlying goal of the MAKE Lab has changed every year since the AM landscape, and how we use it, changes every year,” Ziv said. “We have had around 700 new hires in the last year, many of whom know how to use a 3D printer from college. As a result, we have a two-sided story with a bunch of young people who really know printers, but who only know printers, and not traditional manufacturing. On the other side, we have some individuals who really know traditional manufacturing, but who don’t know the value AM brings. Our goal is to pull both sides together and use this new form of manufacturing where it makes the most sense for our mission.”

Two white 3D printed wedges used to clamp onto eyewash stations. Certain eyewash stations have excess pressure which causes a spill onto counters, so these clamps are used to redirect water to keep it in the sink. (U.S. Navy photo by Scott Ziv)



Carderock Participates in Battery Burning Demonstration

By Todd A. Hurley, NSWCC Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division held a battery burn demonstration involving the Charging-capable Li-ion Autonomous Safe Storage Interservice Container (CLASSIC) on Nov. 4 at the Aberdeen Proving Ground in Maryland.

The demonstration was led by Dr. Thomas Hays, a materials scientist in Carderock's Expeditionary and Developmental Power and Energy Branch.

The battery burn demonstration consisted of Hays and his team purposefully setting fire to lithium ion batteries as a way to show their audience the severity of a potential fire when these batteries are not properly stored. Hays and his team next demonstrated the importance of their product, the CLASSIC, by subsequently setting fire to batteries stored in the CLASSIC to show the lack of hazard in this case. The CLASSIC is intended to be used aboard ships and aircraft as a way

of properly storing these batteries and to mitigate hazards.

"We have been developing safety container technology for lithium ion batteries for all services for years," Hays said. "We do lithium ion battery safety testing, so we are very familiar with the hazards involved. A number of years ago, the Army had issues with smaller batteries catching fire after training exercises or from improper storage. Since we have some experience with other battery container systems, the Army came to us asking for solutions. We approached funding agencies with our idea, which led to this program of how to do containment and firefighting for these batteries."

The overall goal of this demonstration was to get the word out on their product in order to bring the CLASSIC closer to being fielded. In addition to a technology solution to this ever-growing issue, Hays and his team wanted to educate people about the hazards

these batteries pose and that they should be treated accordingly.

The demonstration consisted of three phases. First, Hays and his team set fire to lithium ion batteries under no protection, in order to show the full scope of the dangers of these types of fires.

"The first demonstration was pretty spectacular," Hays said. "We had some burning pieces of the battery fly out almost 75 feet. We even caused a fire in the grass nearby, which had to be put out by the firetruck we had standing by. It did a great job of demonstrating the severity of lithium ion battery fires; in that they are not something you would want yourself or sensitive material near, especially on a ship or aircraft. This first demonstration certainly put on a convincing show of why we are doing this work — that these devices can be dangerous and need to be treated properly."

For the second demonstration, Hays and his team stored the batteries in a disconnected CLASSIC storage locker before setting them on fire.

"We set the same batteries off to show the inherent safety a locker has by preventing fire and debris from getting out," Hays said. "This demonstration led to the venting of some smoke and gas out of the rear locker, which is intended to prevent a pressure build-up."

The final demonstration consisted of using a





Fire and smoke flare up during a battery burn demonstration on Nov. 4, 2021, at Aberdeen Proving Ground in Maryland. Dr. Thomas Hays, a materials scientist in the Expeditionary and Developmental Power and Energy Branch at Naval Surface Warfare Center, Carderock Division, held the demonstration to show what can happen when lithium ion batteries catch fire if they are not properly stored. Hays' team developed the Charging-capable Li-ion Autonomous Safe Storage Interservice Container, or CLASSIC, to contain Li-ion batteries onboard ships and aircraft in order to prevent hazards. (U.S. Navy photo by Dr. Thomas Hays)

Naval Surface Warfare Center, Carderock Division's Charging-capable Li-ion Autonomous Safe Storage Interservice Container (CLASSIC). The CLASSIC is a four feet by five feet by four feet tall container that weighs just under 3,000 pounds. The battery burn demonstration took place on Nov. 4, 2021, at the Aberdeen Proving Ground in Maryland. (U.S. Navy photo by Dr. Thomas Hays)

The aftermath of the first battery burn demonstration with no containment. The battery burn demonstration took place on Nov. 4, 2021, at the Aberdeen Proving Ground in Maryland. (U.S. Navy photo by Dr. Thomas Hays)



fully functioning CLASSIC storage locker.

"Finally, we put the same battery load inside our CLASSIC," Hays said. "We stayed relatively late because we couldn't seem to get anything to happen when abusing the batteries. It wasn't until a little while later that we realized the batteries were actually set off, but that our container responded and put out the fire before we could even realize anything had happened. We expected for there to be a small amount of smoke, but we didn't hear or see anything. This was a better outcome than we had expected."

Although there was not quite as large of a crowd for the demonstration as Hays would

have liked, he is optimistic that he has made an impact, and that his team will continue improving this technology to make it more rugged and versatile.

"There were eight individuals at the demonstration who weren't from Carderock," Hays said. "A majority were from the U.S. Army Combat Capabilities Development Command, which is an Army group that deals with batteries. We also had a fire specialist from the Federal Aviation Administration and a program manager from the Office of the Under Secretary of Defense. We are hopeful that the CLASSIC will be used for commercial

transport in addition to military use."

As Hays and his team continue advancing their technology, they hope to do another demonstration event like this in the near future. Hays also intends to take this technology to the 2022 Advanced Naval Technology Exercise.

"The overall hope is for decision makers to see our product and decide to fund or support us in the technology transition process," Hays said. "Some funding agencies are more aimed towards getting products that have proven to work, so it is nice that we have been able to move into that territory with the CLASSIC."

Navy's Advanced Technology Exercise Showcases NSWC Carderock Capabilities

By Todd A. Hurley, NSWC Carderock Division Public Affairs

The 2021 Naval Integration in Contested Environments (NICE) Advanced Naval Technology Exercise (ANTX) took place from April 7-14 at Camp Lejeune, North Carolina — the same location of ANTX East that took place in the summer of 2019.

"ANTX is one of my favorite innovation events," Naval Surface Warfare Center (NSWC), Carderock Division's Technical Director Larry Tarasek said. "It is where we demonstrate innovative technology to gauge what the fleet's interests and needs are. ANTXs have been going on for the past five years, though Carderock had very little involvement during the first three to four years. I realized we were losing out by not bringing innovation front and center to the fleet. We weren't developing a workforce that got first-hand visibility into what the fleet needs were."

The purpose of the 2021 NICE ANTX was aimed at assisting the Navy and Marine Corps in concept development through the exploration of a wide variety of technology from industry and government labs.

This year's event saw Naval Information Warfare Center Atlantic and NSWC Crane Division as technical leads with the Marine Corps Warfighting Lab and Naval Warfare Development Command as the operational leads. In 2019, NSWC Carderock acted as the technical lead of the event.

"The NICE ANTX is a lot like what we did for the Fight the Naval Force Forward, Logistics, Maneuver and Force Protection ANTX, also known as ANTX East, in 2019," Rodney Peterson said, Carderock's lead ANTX organizer. "The one exception is that the lead roles are different. The focus is still the same — to support the naval forces under the Distributed Maritime Operations concept and Expeditionary Advanced Base Operations."

Specifically, NICE ANTX directly supported the 2018 National Defense Strategy and the NICE Experimentation Campaign. The Stiletto Maritime Demonstration Program, led by Carderock, played a key role in the

execution of the NICE ANTX. Dennis Danko, who manages the Stiletto program under Carderock's Combatant Craft Division's (CCD) Special Projects Branch in Virginia Beach, supported a total of 10 technologies at the NICE ANTX, with several of the technologies to have follow-up demonstrations on Stiletto in the future.

"Stiletto is a maritime demonstration and

space, land, maritime and cyberspace.

"The focus area leads guide a set of participants that are demonstrating technologies at the ANTX in keeping them informed and helping them understand what to expect at the ANTX event itself," Peterson said. "Some of them have only demonstrated their technologies on land and were excited for the opportunity to try their technology over water, be it the Inter



experimentation platform with a mission of supporting the Rapid Reaction Technology Office in countering emerging threats by conducting demonstrations to validate the technical feasibility of a capability, explore its operational value and reduce developmental risk," Danko said. "We take new, innovative, emerging technology, put them on boat, get underway in a relevant environment and evaluate their performance capability. This is a good way to reduce developmental risk and introduce new technology to warfighters, industry and other companies."

Peterson was present at the NICE ANTX as a focus areas (FA) lead in order to provide guidance to vendors and participants. He led Domain Maneuver, one of five FAs for the employment of friendly forces, and capabilities to gain an advantage over the adversary in air,

Costal Waterway or the ocean."

Carderock had four technology demonstrations at this year's event.

One of which being the Autonomous Lab and Integration Center (ALICe), which led a demonstration with their unmanned surface vessel (USV), Hammerhead Hanna. This program is led by Carderock's Plinio Vargas, a computer scientist in the USV Controls Engineer Resource. Carderock's Jeffrey Smith, the Technical Project Manager in the Research and Development Systems Engineering Division was the onsite lead for the ALICe demonstration during the event.

"ALICe is unique because its capability was developed for all of the Department of Defense (DOD), not just the Navy," Carderock's Dr. Julie Stark said, the Science

and Technology Office Department head. “With ALICe being at ANTIX it has access to high visibility with a lot of eyes on it that wouldn’t usually see it. We hope that this will lead to collaboration among the rest of the DOD.”

ALICe was also featured at the ANTIX East in 2019, though its primary focus then was autonomous refueling. This go-around, with the help of a Small Business Innovation Research video camera attached to vessel, the ALICe team decided to further demonstrate their capabilities.

“This year we decided to do an intelligence, surveillance and reconnaissance mission,” Vargas said. “We installed the video camera on our vessel to identify targets and to provide us with a constant live feed. We autonomously undocked from the pier, transited the channel and went into a harbor, and then used the camera to identify any targets. When we went into the bay we could see what vessels were nearby and were able to send a report back to say what vessels were located. Then, after identifying the targets, the vessel autonomously came back and docked itself.”

There was, however, a major malfunction that occurred to Hammerhead Hanna, but the ALICe team responded quickly and precisely to ensure it was repaired in impressive time.

“Everyone wants to think you can hit an easy button and everything will be fine with an

autonomous vehicle, but that’s not the case,” Stark said.

During the ANTIX, Stark said the ALICe USV experienced an equipment failure rendering the boat inoperable. CCD personnel were able to acquire a spare part (from another boat), repair the damaged propulsion system component and perform all necessary modifications to return the USV to operational status in fewer than 24 hours.

“If this had happened during a real life mission, this could have been catastrophic to mission success,” Stark said. “This incident highlights the importance of total system considerations for all unmanned vehicles including maintenance, logistics, sustainment, and especially having the correct personnel trained and available to deal with potential failures in a timely manner to ensure continued mission success.”

Also present was the Asymmetric Industrial Warfare (AIW) led by Carderock’s Garry Shields, the Director of the Disruptive Technologies Lab.

“We train as to how we fight, and we fight as to how we train,” Shields said.

The AIW is a forward-deployed, tactically relevant, ‘on-demand’ manufacturing capability enabling warfighters to insert expendable vehicles, platforms and structures.

“We specialize in building expendable platforms,” Shields said. “We have been able to train Marines how to build expendable rafts, shelters, docks and piers. We help them with changing their perspective of materials you build with.”

One way to do that is to build and demonstrate a raft made out of presumably abnormal materials.

“The main thing we demonstrated at the ANTIX was a raft made of foam and bamboo, which is capable of transporting four thousand pounds,” Carderock’s Mark Melendez said, a mechanical engineer and member of Shields’ AIW team.

This experience is not one the members of Shields’ AIW team will soon forget.

“Being able to participate in the ANTIX has been very exciting from a Carderock engineering perspective to work closely with the Marine Corps and learn their ideas on tactically relevant platforms,” Carderock’s Bruce Wells said, also a mechanical engineer and AIW team member.

The Charging-Capable Li-ion Autonomous Safe Storage Interservice Container (CLASSIC), led by Carderock’s Dr. Thomas Hays, a materials scientist in the Expeditionary and Developmental Power and Energy Branch and Justin Warfield, an electronics technician in the Non-Metallic Materials Research and Engineering Division, was another technology present at this year’s ANTIX. The CLASSIC safely transports, charges and stores fully charged lithium-ion batteries insulating personnel and platforms from battery hazards.

“Vice Adm. James Kilby and Mr. James Geurts were present for one day of the NICE ANTIX and they got a first-hand look at one of our technologies — our CLASSIC,” Tarasek said. “ANTIX has been a great opportunity for our folks to engage with senior Navy leadership.” Kilby is Deputy Chief of Naval Operations for Warfighting Requirements and Capabilities;

Continued on next page

Carderock’s Autonomous Lab and Integration Center team demonstrating their unmanned surface vessel, Hammerhead Hanna, along the Intracoastal Waterway near Camp Lejeune, N.C., at the 2021 Naval Integration in Contested Environments Advanced Naval Technology Exercise on April 21. U.S. Navy photo by Eric Silberg)

Carderock’s Matthew Raphael and Eric Silberg demonstrating their Magnetic Anomaly Detection from an Unmanned Aerial Vehicle (MADUAV) at Onslow Beach near Camp Lejeune, N.C., at the 2021 Naval Integration in Contested Environments Advanced Naval Technology Exercise on April 20. The MADUAV is a forward-area magnetic signature measurement capability for detecting the fleet’s susceptibility. U.S. Navy photo by Eric Silberg)



INNOVATION

AT WORK



Continuation from previous page

and Geurts is now performing the duties of Under Secretary of the Navy.

Finally, Carderock's Eric Silberg, an aerospace engineer in the Sea-Based Aviation and Aeromechanics Branch co-led the demonstration of the Magnetic Anomaly

Detection from an Unmanned Aerial Vehicle (MADUAV) with Matthew Raphaely of the Research and Technology Development Branch. The MADUAV is a forward-area magnetic signature measurement capability for detecting the fleet's susceptibility. As with all the technologies participating in ANT-X, the MADUAV is still in its emerging phase.

"This product is still very much developmental, but I think our time at the ANT-X went really well," Silberg said. "There was a lot of opportunities to do testing on the beach — we did a number of flights with various different aircraft."

For Silberg, the NICE ANT-X provided not only a good opportunity to showcase his team's up-and-coming technology, but provided critical, unbiased feedback.

"From a technical standpoint, this event provided a great opportunity for testing, with a lot of good conversations with Marines, Navy officers and tech assessors who all brought good ideas on how it could be used, where it can be useful and where it won't be useful," Silberg said. "As a technology there is a lot of value in coming in with an open mind to input you'll receive, especially being in developmental phase, it is important to have the ability to remain adaptable to input you'll receive."

Peterson said he was proud of the work the Carderock teams did in showcasing their technologies and talents, saying, "All of the Carderock technologies did very well and received good attention."

Aside from the technology demonstrations, Carderock also provided four engineers to support technical assessments as part of a team

of nearly 150 individuals from Naval Research and Development Establishment and Navy and USMC military operators.

Carderock's team of technical assessment engineers consisted of: Anthony 'Tony' Blair and Alex Gruber, engineers in the Test and Evaluation Engineering Resource Branch; Marella Camello, an engineer in the Research and Technology Development Branch; and Ryan Franke, an engineer in the Subtractive and Additive Manufacturing Branch. Also present was Marco Leo, a new Carderock employee at CCD who provided logistics support.

"The typical day of technical assessments consisted of Marines, Sailors, Navy engineers and scientists going from technology to technology spending about an hour with each and hearing about the technology and how it operates. They recorded their thoughts after each session and moved on to the next." Being a tech assessor is probably the hardest job at the ANT-X," Peterson said.

Tarasek views ANT-X as an excellent opportunity to better Carderock's workforce development.

"The key takeaway from this year's ANT-X, or any ANT-X we participate in, is the ability to develop a workforce that understands what the fleet of today needs for the ships of the future," Tarasek said. "It is important for us to resolve today's fleet problems through innovation."

Going forward, Carderock fully intends to make its presence known at future ANT-Xs.

"I think the NICE ANT-X went really well this year — ANT-X will continue to be a part of how we invest our Naval Innovative Science and Engineering money," Tarasek said. "These last two ANT-Xs have shown the value of supporting fleet exercises."

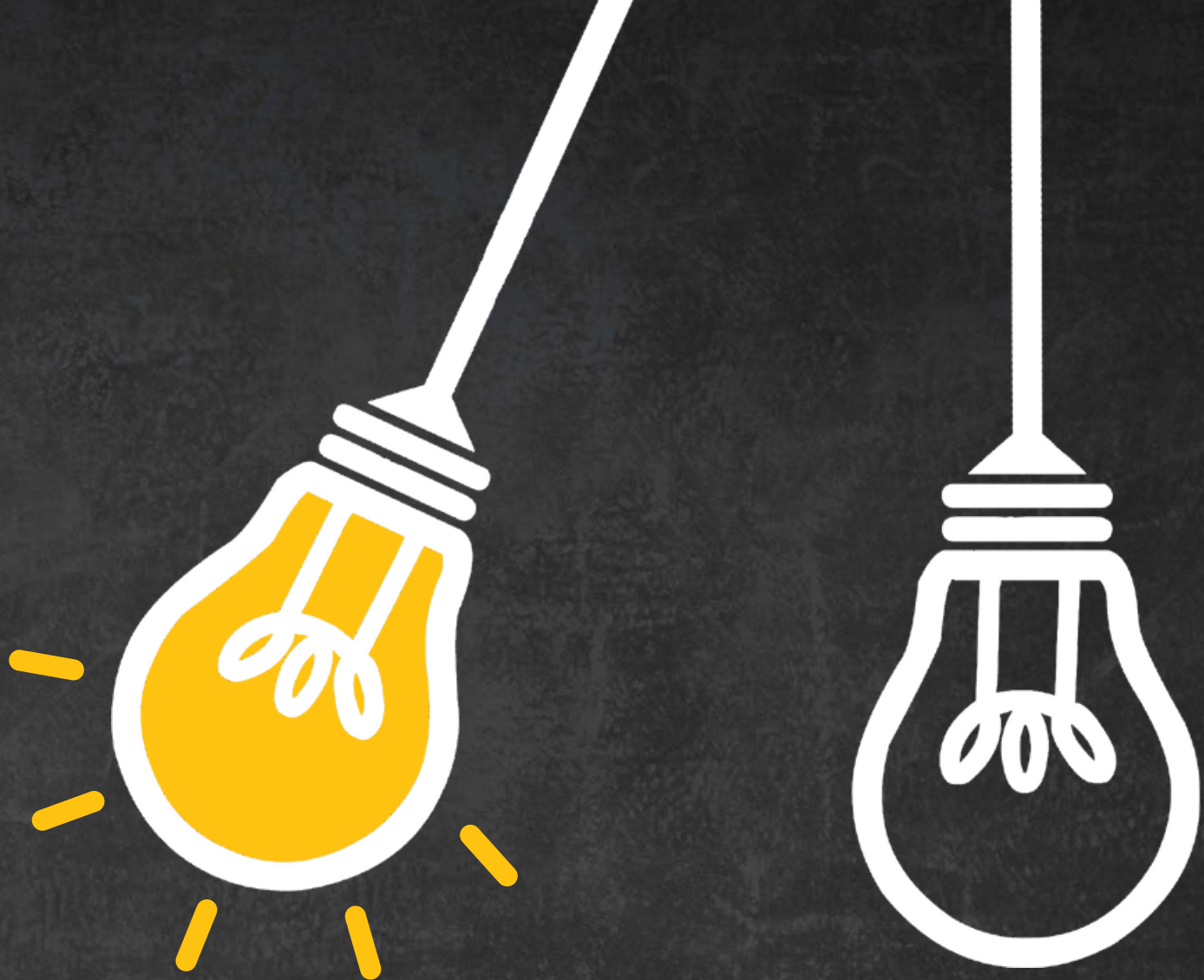
Peterson was proud to announce that due to strict safety protocols and social distancing, the event experienced zero positive COVID-19 cases among the more than 500 individuals present.

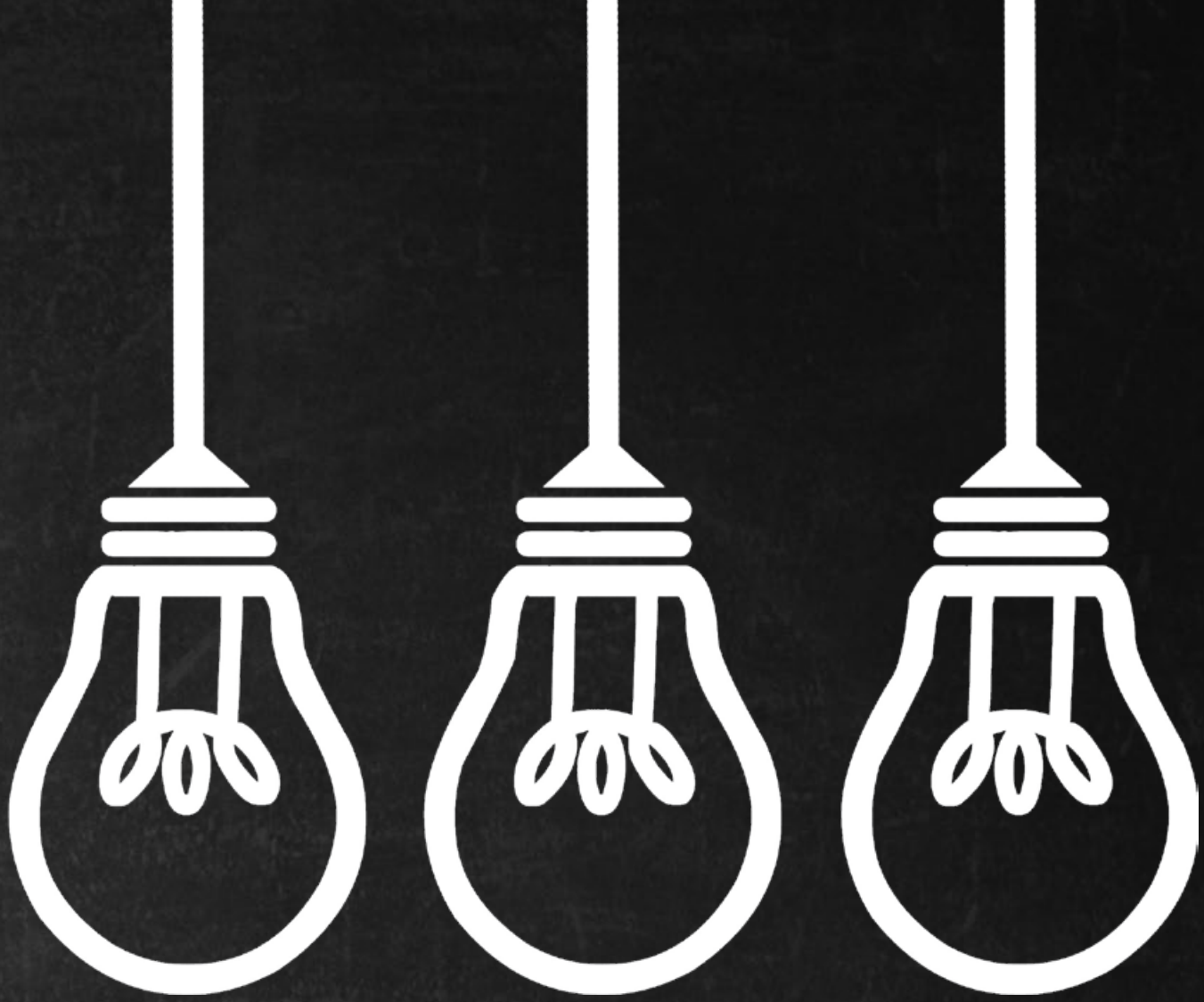
The Stiletto Maritime Demonstration Program platform supported the 2021 Naval Integration in Contested Environments (NICE) Advanced Naval Technology Exercise (ANTX) in Camp Lejeune, N.C., on April 12. Stiletto is a maritime demonstration and experimentation platform that helps to counter emerging threats by conducting demonstrations to validate the technical feasibility of a capability, explore its operational value and reduce developmental risk. Stiletto supported 10 different technologies at the 2021 NICE ANTX. (U.S. Navy photo provided by Eric Silberg)

Carderock's Asymmetric Industrial Warfare (AIW) team, led by Garry Shields, demonstrating their raft made of foam and bamboo along the Intracoastal Waterway near Camp Lejeune, N.C., at the 2021 Naval Integration in Contested Environments Advanced Naval Technology Exercise on April 12. The AIW team specializes in building expendable platforms such as rafts, shelters, docks and piers. (U.S. Navy photo by Victoria Baker)



Carderock's Charging-Capable Li-ion Autonomous Safe Storage Interservice Container demonstration station at the 2021 Naval Integration in Contested Environments Advanced Naval Technology Exercise on April 12 in Camp Lejeune, N.C. This technology safely transports, charges and stores fully charged lithium-ion batteries insulating personnel and platforms from battery hazards. (U.S. Navy photo provided by Teresa Ovalle)





PATENT SPOTLIGHT

Patent Spotlight

Multilayer Composite Structure

By Benjamin McKnight III, NSWC Carderock Division Public Affairs

The earliest documentation of armor designed with ballistic protection in mind can be traced back to the Bullet-proof Cuirass in 1908 (U.S. Patent No. 1003270A).

In the 100-plus years since that initial patent, the technological advancements in ballistic protective materials have improved exponentially. More discoveries are being made to this day, and a duo of engineers at Naval Surface Warfare Center, Carderock Division, recently earned a patent for their recent development in the field.

U.S. Patent No. 10,751,983, “Multilayer Composite Structure Having Geometrically Defined Ceramic Inclusions,” was awarded to Carderock’s Brandon Good of the Emerging Technology Branch and Jonathan Krufft of the Non-Metallic Materials Research and Engineering Branch in August 2020. This achievement was a culmination of nearly three years of dedicated research and experimentation by the two.

While many inventions are jumpstarted by a triggering event, Good said that the origins of their work was nothing more than the natural progression of conversations in the ballistic research circles.

“There wasn’t that news event or something that occurred,” he said. “It just kind of came out of those different communities indicating this is something they could potentially use.”

According to the patent, while composite structures are typically designed with the structural supportability as the main focus,

modern-day practices encourage dual functionality or more. Stopping bullets is the first function that comes to mind when thinking of armored material, but the second property the duo decided was a necessary addition was electromagnetic energy absorption. Creating a structure with both ballistic and electromagnetic functionality is no easy task, but the duo appears to have found a solution by introducing a geometrical inclusion methodology in their addition of ceramics to the composite structure.

“We began this project surveying the ballistic and ballistic material community for ‘rules of thumb’ to defeating the target projectile and velocity,” Krufft said, who worked with the Navy’s armor experts in Carderock’s Hull Response and Protection Branch to develop these rules of thumb. “The biggest challenge was staying true to these ballistic concepts while tailoring the composite to control

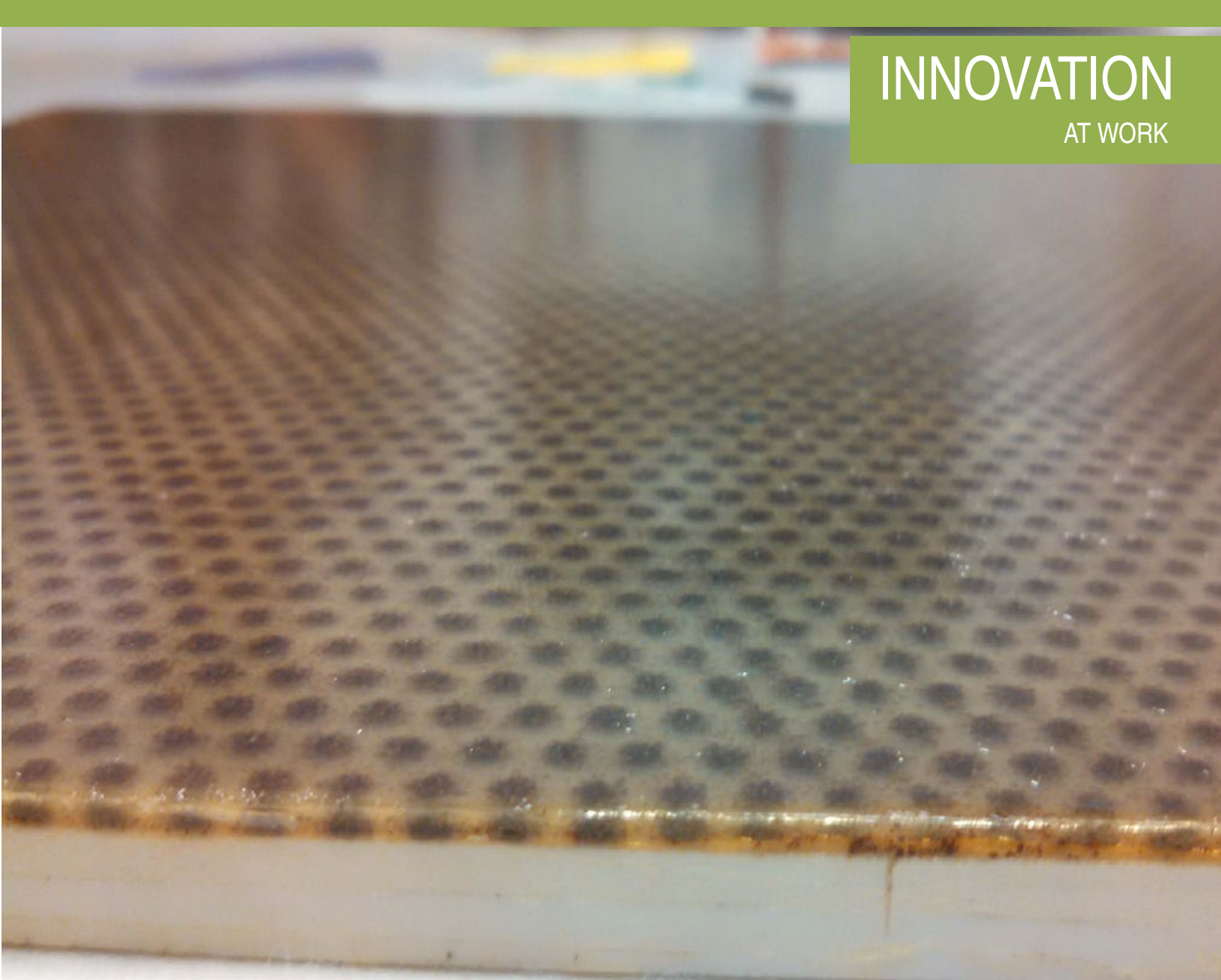
electromagnetic energy propagation.”

Determining the electromagnetic properties of the material took priority once the duo started the fabrication process. To reach a satisfactory level of electromagnetic response performance, Good said the structure needed to effectively minimize reflection from electromagnetic waves. This was done utilizing an iterative design process. After each constituent layer was measured for electromagnetic properties, they were imported into a model which Krufft said was again adjusted to optimize performance. The fabrication was broken down into six phases where partial prototypes were evaluated and measured against the model at each phase’s conclusion.

“We came up with an anti-reflective surface for our ceramic by trying to minimize the reflection of the side of the ceramic,” Good said. “Essentially, we measured the ceramic

One of the prototypes Naval Surface Warfare Center, Carderock Division’s Jonathan Krufft and Brandon Good developed as they worked to create a Multilayer Composite Structure Having Geometrically Defined Ceramic Inclusions (U.S. Patent No. 10,751,983). This specific structure had just completed ballistic testing, indicated by the three markings of rounds fired at the structure. (U.S. Navy photo by Jonathan Krufft)





and a bunch of different geometrical layers. Then, working with our electromagnetic codes at Carderock, we were able to build up a design that achieved anti-reflective properties for that ceramic.”

Following the prototype creations, Krufft said that ballistics testing was conducted at the Aberdeen Test Center ballistics range. Krufft worked with Joe Walther in Carderock’s Hull Response and Protection Branch to ensure that the test methodology was sufficient for comparative evaluation of the ballistic performance to legacy materials. The samples were subjected to three shots in an equilateral triangle pattern of 120mm per side.

Krufft and Good took a risk in assuming that, by saving ballistic testing until after the prototypes were complete, the material would pass the latter assessments. In fact, they were initially unsure if the project was even possible when they discovered the required

thickness and ceramic density needed to defeat projectiles.

“I think that was the biggest thing to overcome, learning ballistics,” Good said. “Like anything, there’s a bit of nuance to what works, and people don’t always understand exactly why. We had to do a lot of learning in regards to what was unique, and what had or hadn’t been done.”

The end result was the creation of a five-layer structure containing the following: low-density, high-strain-rate polymer 850; hybrid composite fabric 820; inventive composite 650 with ceramic inclusions 50; ceramic plate 830; and high-strain-rate polymer ballistic fabric 840. Although there is not an immediate demand for the invented structure, understanding the techniques behind creating this form of structure is something Krufft said will benefit material designers – and the Navy as a whole – in the future. The materials

A side view of two of the internal layers of the prototype for the Multilayer Composite Structure Having Geometrically Defined Ceramic Inclusions (U.S. Patent No. 10,751,983). (U.S. Navy photo by Jonathan Krufft)

and processes identified during prototype development are now part of the core competencies and library of techniques the Navy can adopt to any number of customer electromagnetic applications.

“When the challenge arises, we want to be able to address it,” Good said. “When does that critical need come into play? Will it be five years from now? We don’t know, but we have seen people trying to address multifunctional materials, and this is a method that we have confidence will address both ballistic and electromagnetic issues.”

Patent Spotlight Hydrodynamic Flow Separation Device for an Axisymmetric Bluff Body

By Todd A. Hurley, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division employees have received a patent for their hydrodynamic flow separation device.

On Jan. 26, 2021, engineers Dr. David Coakley, Stephen Shepherd and David Newborn, all from Carderock's Maritime Systems Hydromechanics Branch, were awarded a patent for a Hydrodynamic Flow Separation Device for an Axisymmetric Bluff Body (U.S. 10,899,417).

Though it has general applicability, the device was specifically designed for the Mine Warfare Program's (PMS 495) AQS-24C mine-hunting vehicle.

"A few years ago PMS 495's AQS-24C mine-hunting system approached us about their towed vehicle that was behaving poorly," Shepherd said. "The vehicle was unstable with a severe yaw instability. A squat, relatively large diameter cylinder known as the Atlas

sonar had been integrated on the aft portion of the vehicle. This body improved the acoustics used in mine-hunting, but created the hydrodynamic instabilities caused by flow separation on the cylindrical body. In order to fix it we had to remove the cylinder, but that would defeat the purpose. Instead, Coakley had the idea to take the flow and redirect it onto the after portions of the curved surface of the cylinder to cause flow separation, resulting in no net transverse force. With this we were able to come up with the idea for the patent."

The invention relates to the hydrodynamics of bluff bodies: a body that has separated flow over a substantial part of its surface. More specifically, it relates to the methods and apparatuses for altering the hydrodynamics associated with a bluff body at aft end of a marine vessel. The invention provides for an attachment of a pair of waterjet-streaming devices at opposite axial ends (in this case port and starboard sides) of a bluff body. The

devices then discharge the streams of water, deflecting and or detaching the hydrodynamic flows on both curved side surfaces of the bluff body.

"Flow separation around the circular sterns of additional equipment causes flow instability, and so several solutions across the nation were proposed," Coakley said. "We had a novel solution to take the dynamic pressure due to the vehicle motion and channel it downward in a region of the circular stern to force the unstable configuration into a stable configuration."

In essence, the invention provides a hydrodynamic stabilization apparatus for mitigating lateral swing instability, and is also capable of effecting continually self-stabilizing movement in an environment of air or water.

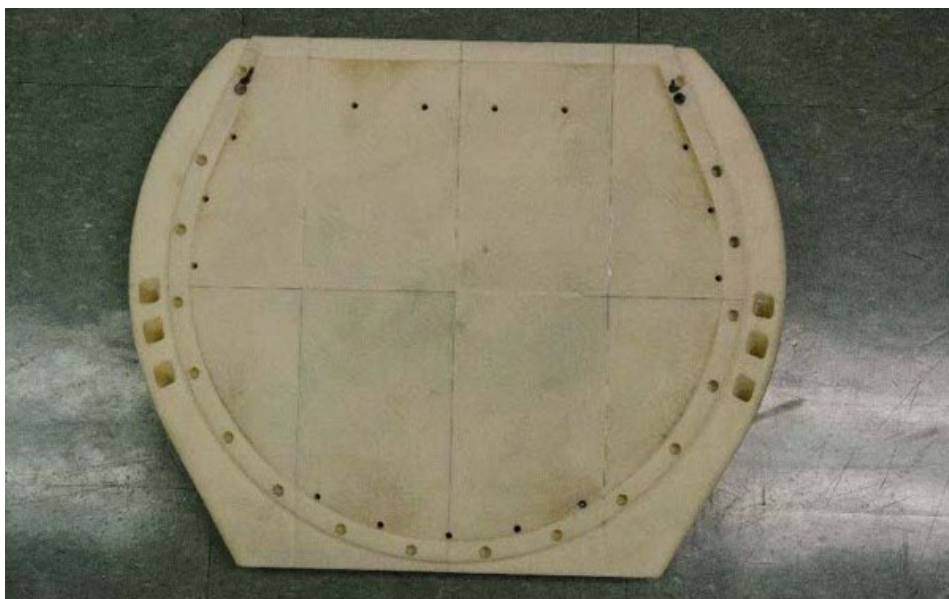
Testing for the device took place in September 2017, but the trio came up with the idea months beforehand.

"We had to figure out how to make this thing — Coakley and I went back-and-forth with the design, which took about a month," Shepherd said. "We were able to 3D print the prototype in pieces and used adhesive to put it all together. We had the 3D printer going at all times for a week or two. After it was printed, Dave Newborn assembled it and shipped it to us at the testing site in Memphis, Tennessee, at the Large Cavitation Channel."

Coakley added that, "We did not know if it would work, so we used our best engineering judgement and built the model. Newborn orchestrated the 3D printing, Shepherd did the mechanical design and I did the hydro-design. It was designed and built rather quickly: low and behold it worked."

Ultimately, though, it was not the solution that was selected to resolve the issue.

"Another fix was selected because it had less questions associated with it and had a more simple design," Coakley said. "Our design was tested on AQS-24 Atlas sonar, and that is the only prototype ever tested anywhere. While it did work, our design was not optimized, and it definitely could be improved. There is currently no plan to do anything with it. The concept is relatively unexplored."



The up-close look of the Flow Separation Device, fully detached before being put to use on Sept. 20, 2017, at the large cavitation water channel facility in Memphis, Tenn. (U.S. Navy provided photo by Stephen Shepherd)

Patent Spotlight

NSWC Carderock inventors patent Device for Non-Lethal Stoppage of Water Jet Propelled Craft

By Todd A. Hurley, NSWC Carderock Division Public Affairs

The patent, U.S. Patent 10,323,911 B1, Device for Non-Lethal Stoppage of Water Jet Propelled Craft, was introduced during Naval Surface Warfare Center, Carderock Division's first Engineers Week event. It was granted to the six Carderock co-inventors on June 18, 2019, though it was submitted in 2016.

"My role with patents is dual-hatted — I'm the Maritime Systems Hydromechanics Branch head and the Naval Architecture and Engineering Department representative on the Invention Evaluation Board," Carderock's Damien Bretall said. "This idea came about for a project that was in collaboration between Carderock personnel at West Bethesda and the Combatant Craft Division. Like a lot of people at Carderock, we were trying to solve a very unique problem — something that on the surface might not seem like that big of a deal, but actually once you dig into it, it becomes very complex."

The problem they tried solving was how to stop a personal watercraft, such as a Jet Ski, in a non-lethal manner.

"There's a lot of reasons you might want to stop one — it could be something that could be headed toward a naval asset, they could be drug-running and could be getting away," Bretall said. "The simplest conventional way, of course, is to use kinetics and artillery, but that's only appropriate in some situations ... there's a lot of reasons you might want to stop a Jet Ski non-lethally."

The engineering goals of the device were for it to be non-lethal to the watercraft operator, to minimize irreversible damage to the vessel, and to be removable without having to lift the vessel out of the water. The device had to degrade in the water over time and be quickly deployable from a safe distance.

Other engineering goals included being heavy enough to launch, stable enough to fly straight, neutrally buoyant, long enough to

reach the waterjet inlets, soft enough to not suddenly stop the impellers or damage the blades, flexible and malleable enough to fit through grate openings and tacky enough to stay on the impeller blades and block flow or occlude generated thrust.

The biggest challenge the inventors faced was figuring out how to get their device from a ship or boat into the impeller.

The solution was essentially a standard, off-the-shelf, t-shirt cannon that shoots out the device. The device has a weighted head and tentacles that float to the surface, which will ideally get stuck in the shaft of the vehicle, causing it to lose propulsion. After various model-scale tests at the David Taylor Model Basin, the full-scale testing took place at the Oil and Hazardous Materials Simulated Environmental Test Tank outdoor basin in

New Jersey.

"What we came up with meets most of the engineering goals," Bretall said. "A lot of Carderock inventors initially think, 'Ah, this is so obvious, I can't believe someone hadn't come up with this,' but, you have to remember, you are sometimes addressing a problem that no one in the world has ever needed to address. Even if it's something that might be obvious to you, it's definitely worth seeing if it's been done and patented."

Bretall and the other inventors are currently trying to figure out a home for their device.

"The future for the device is still unclear," Bretall said. "Some things you get a patent for end up getting a lot of attention, and others don't. We'll have to wait and see what comes of this one."

In addition to Bretall, the patent was co-invented by five other individuals, four of whom are still at Carderock. Andrew Krauss, a mechanical engineer in the Maritime Systems Hydromechanics Branch was the lead on the invention. The other inventors include: Alma Jacobson, the Branch head of the Research and Development Systems Engineering Branch; Steve Brandis, a technician in the Naval Architecture and Engineering Department; Ryan Faber, a naval architect in the Test and Evaluation Engineering Resource Branch; and Chelsea Shores, a previous Carderock employee.



A standard, off-the-shelf, t-shirt cannon is used to shoot out the device for non-lethal stoppage of water jet propelled craft. (U.S. Navy photo provided by Damien Bretall)

Patent Spotlight

Supercoupling Power Dividers, and Methods for Making and Using Same

By Benjamin A. Morley, NSWC Carderock Division Public Affairs

Matthew Byrne, an electrical engineer in Naval Surface Warfare Center, Carderock Division's Target Strength and Airborne Noise Branch, was awarded U.S. Patent 11,044,549, Supercoupling power dividers, and methods for making and using same, on June 22, 2021.

The patent was issued to co-inventors Matthew Byrne, Dr. Hussein Esfahlani and Dr. Andrea Alù. The invention, a supercoupling power divider, was a result of research Byrne and his team conducted during his doctoral studies while working with an academic team at the University of Texas (UT) at Austin.

While studying at UT Austin, Byrne's academic advisor, Alù, introduced him to an academic challenge of experimentally demonstrating the phenomena of acoustic supercoupling.

A system is described as exhibiting supercoupling when the transmitted waves have the same phase and full amplitude, regardless of the length or geometrical bending that takes place in the coupling channel.

Ordinarily, sound passing through a coupling channel would lose power, reflect or change phase while passing through the system. Supercoupling was demonstrated theoretically for sound, but never in experiments.

"We were just interested in basic research, not trying to invent anything," Byrne said. "Our academic advisor posed the problem to observe acoustic supercoupling without requiring periodic membrane resonators. The previous theory required many membranes embedded within the coupling channel."

The primary hurdle to realizing acoustic supercoupling from a practical engineering perspective was the reliance on the periodic membrane resonators. In theory, the phenomena could be produced by changing parameters in the simulation. In theories showing supercoupling, the membranes were used to tailor the effective material properties of the coupling channel, which resulted in acoustic supercoupling. In practical implementation, this proved difficult as the membranes needed to be constructed to exact specifications and had to match under very specific conditions that could be difficult to reliably replicate. Byrne and the team looked for another way to solve the supercoupling conundrum.

Trying to solve the problem of supercoupling without the theoretically proven membranes posed a trade-off for the team, as they pursued a method for performing supercoupling via a compressibility-near-zero (CNZ) approach.

Membrane-free supercoupling came with greater size and higher stiffness requirements to avoid acoustic leakage. While it was possible to create supercoupling without the membranes, the solution might not have been feasible.

However, the solution came from off the shelf, literally.

"We chose the welder's toolbox to address the acoustic leakage, weight and budget constraints" Byrne said.

The team wanted to demonstrate that it is possible to use something like a standard tool box, which does not have perfectly parallel sides, to show that acoustic supercoupling can be achieved with practical types of construction. This not only proved the concept, it showed that supercoupling can be performed with less difficulty and at lower costs.

The supercoupling concept was further developed into a device called a power divider, which allows for the customization of sound transmission. Conventional systems are more geometrically complex and suffer loss of acoustic power from reflection, absorption and other sources of acoustic leakage. The supercoupling power divider solves these problems and allows for enhanced capabilities with existing systems and new paths forward for future technologies.

The device also allows for acoustic power to be

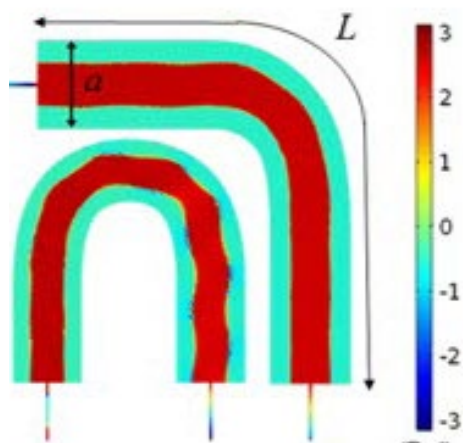
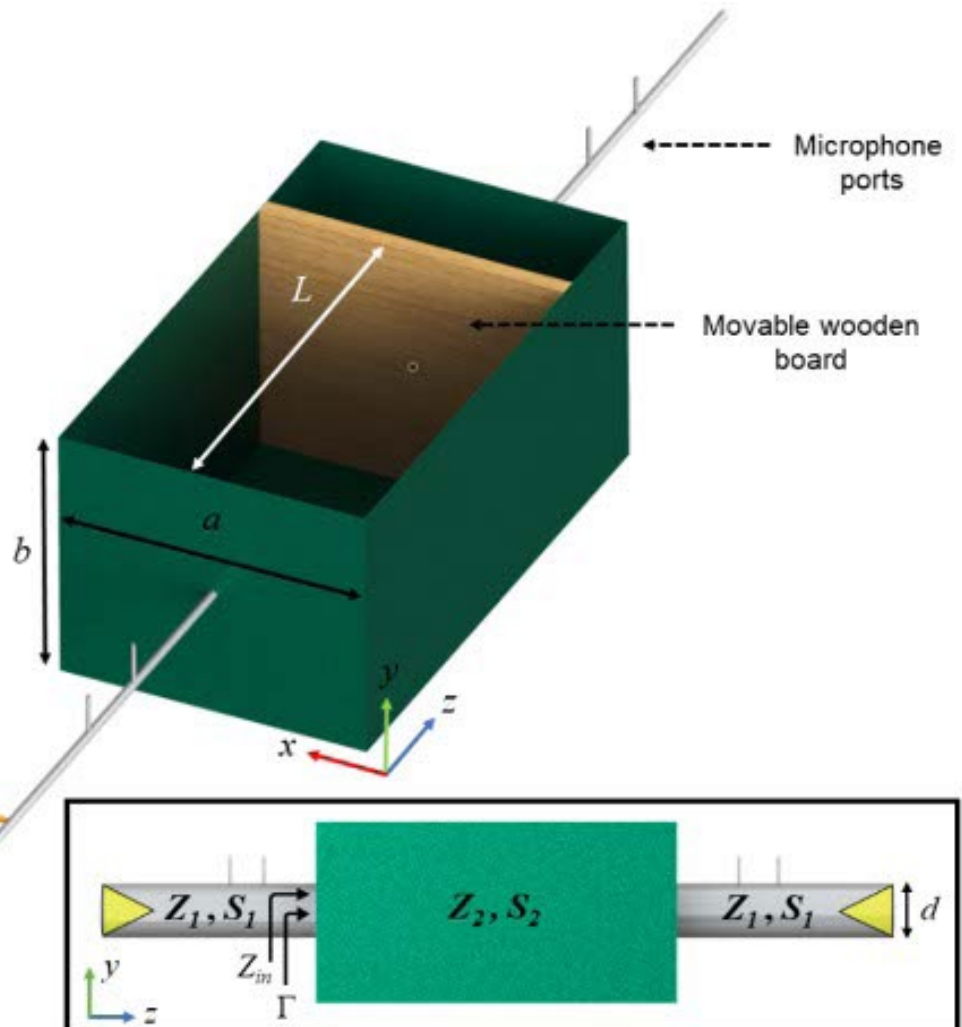
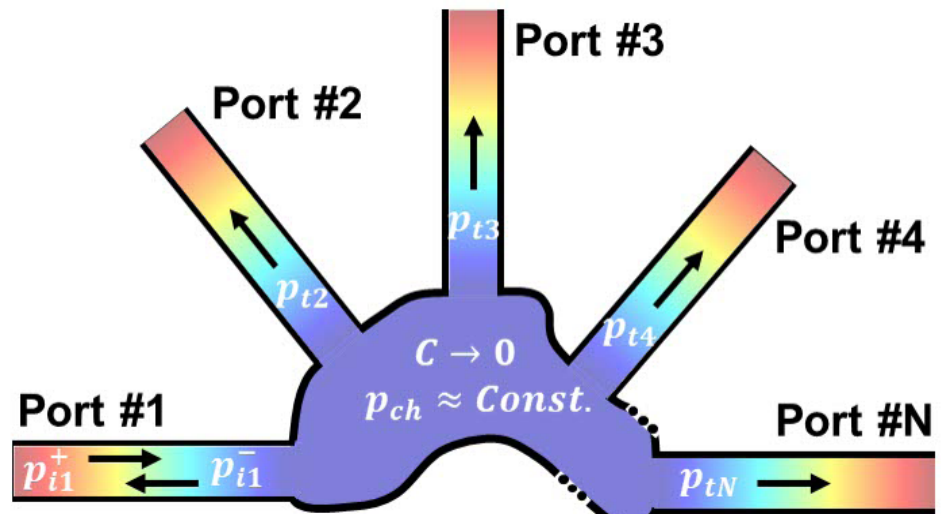


Figure 1: An acoustic power divider with compressibility-near-zero effective material properties. (Graphic provided by Matthew Byrne)

Figure 2: Experimental setup for validation of compressibility-near-zero supercoupling. (Graphic provided by Matthew Byrne)

divided in an arbitrary way, and in principle, without resulting in any power lost during the process. Power fed through the device will be uniform throughout the system due to the CNZ material's properties, allowing acoustic waves to pass through with uniform phase while preserving acoustic energy throughout the system. As the supercoupling power divider is designed with impedance matching, the power that is transmitted will not result in any sounds reflecting backwards. The power divider can result in new sensing technologies and lower the cost, weight and space constraints of future iterations of these acoustic technologies.

Figure 3: Conceptual drawing of an acoustic power divider with compressibility-near-zero effective material properties. (Graphic provided by Matthew Byrne)



Patent Spotlight

Patent Awarded for Radiological Criticality Dosimeter Using Same

By Courtney Jones, NSWC Carderock Division Public Affairs

In November 2016, Dr. Luis Benevides, a retired Navy captain and current radiation safety officer in Naval Surface Warfare Center, Carderock Division's Safety Branch, had an idea to design a dosimeter to monitor and measure nuclear criticalities using elements like gold, tin and

sulfur incorporated in 3D-manufactured material. Inside that material would contain nanoparticles used for the dosimeter's intended purposes. On June 8, 2021, Benevides and his co-creators successfully received a patent (Radiological criticality dosimeter using nanoparticle technology

in additive manufacturing, U.S. Patent 11,029,428) for the device.

He compared the device's potential to a movie scene.

"If you've ever seen the movie 'The Manhattan Project,' there was a scene where two individuals



Differential Scanning Calorimetry Analysis of the AuNP loaded PLA. (Graphic provided by Dr. Luis Benevides)

were playing around with a ball of radioactive material, and when they close the ball, there was a blue flash," Benevides said.

That blue flash is commonly called a nuclear criticality event.

"There's a burst of neutrons that occur, and when they interact with humans, it can cause severe damage and even death," he said.

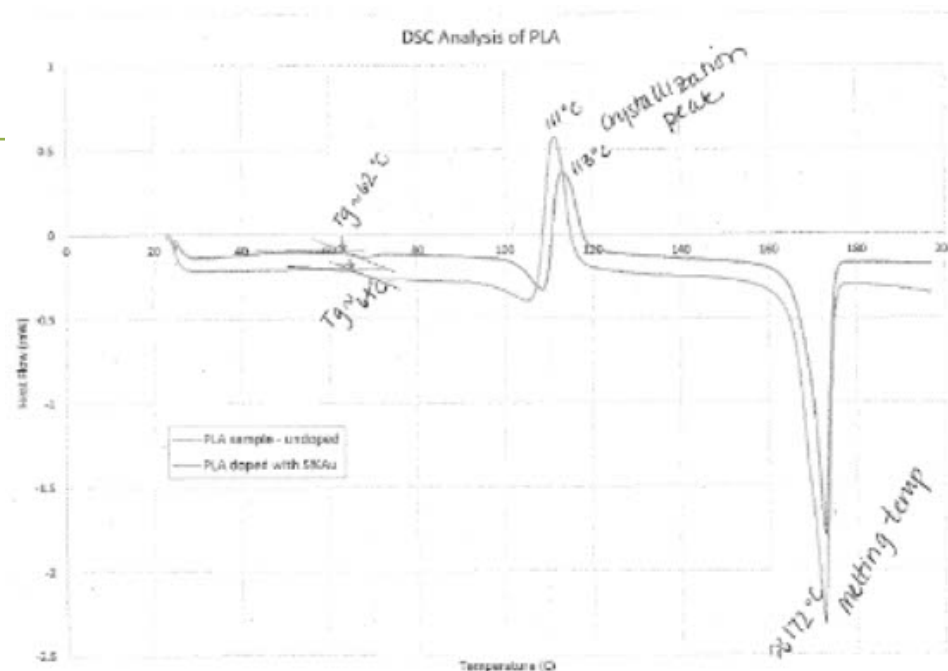
Benevides noted that while a dosimeter such as this one may not have saved those movie characters, it would have explained the details of the criticality and provided insight to prevent future incidents.

"I had the idea of finding a way to incorporate these nanoparticles into additive manufacturing. Unfortunately, I did not have the technology," Benevides said. "Then during ongoing meetings with colleagues, who I had worked with while earning my degree at University of Florida in Gainesville conducting experiments on a reusable therapy fiber dosimeter, we soon developed an idea into an application."

Alan Huston and Brian Justus, patent co-creators from the U.S. Naval Research Laboratory, have been long-standing colleagues of Benevides', and meet semi-annually to discuss various experiments and materials each are thinking about and testing.

When Benevides began brainstorming this device, his co-inventors mentioned that they had a colleague, Barbara Marcheschi, working on a method to create nanoparticles for a variety of biological applications, such as contrast agents, delivery vehicles and therapeutics. The four felt that this novel approach had merit, and they moved forward to develop it.

Once they created the material, Benevides tested it with another colleague, Marshall Millette, who allowed him to use a subcritical nuclear reactor at the U.S. Naval Academy to evaluate the newly minted material. Upon testing, the results immediately showed that



this method was a viable approach.

Benevides also credits Dawn Russell, a patent attorney at Carderock, who was instrumental in putting the patent package together. He noted that it required a lot of back-and-forth, in which she had to translate conceptually complex information into legal terms.

"We had to convince her of what we were doing because she would have to defend that to the patent office," Benevides said. "I came up with the idea, they had the technology and we put it together to create the material. It just happened to be coincidence that Huston and Justus were working on the same materials to synthesize water-soluble gold particles. Gold is one of those materials that is unique for what I was trying to do."

From conception to creation, the entire process took three years.

"From the concept in 2016, we had the material in 2019 primed and tested," Benevides said.

He noted that the current dosimeter technology in the Navy was first designed in 1968. However, over the years, the material has become environmentally corrupted from air exposure and oxidation.

"We were trying to replace it; however, everything we tried to replace it with was the same technology," Benevides said. "The technology had not progressed over time, so I was just thinking outside of the box and started writing some notes."

"There have been several of these accidents over time across the world, so this material would be usable in all those events," Benevides said.

"Because it's 3D printing technology, it allows the user to print it into a variety of geometries, such as picture frame, slab or small blocks that can be hung on the wall. Then, if a criticality happened, you would take it off the bulkhead or wall and get all the needed information."

To date, this application has not been utilized as a dosimeter.

"We have not had any of these incidents; however, we do monitor for these events and have devices in place to monitor," Benevides said.

He mentioned that other facilities, like nuclear power plants and nuclear fuel plants, would also have use for this type of technology application.

Benevides said while this device is a vast improvement over the older model, there was potential for enhancements. As part of the patent, he proposed that the material could be incorporated into the Navy's existing personnel dosimetry.

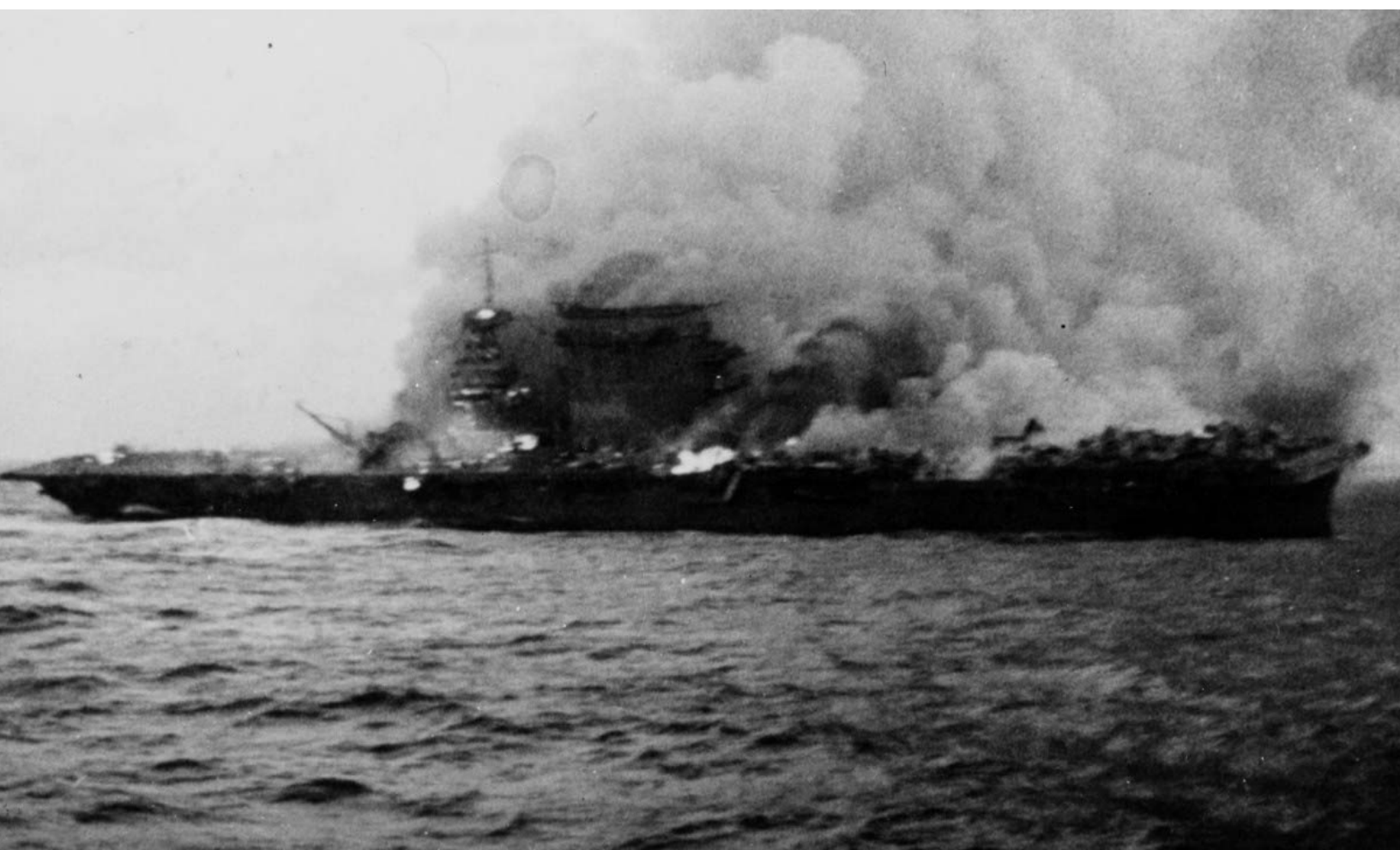
"There were plenty of improvements we could have made, but we did not have the funding to support it," he said.

However, Benevides stated that the Navy's older dosimeters are in the process of replacing the technology of the late sixties.

This is not Benevides's first patent. He also received a patent for developing a temperature verification device for the dosimeter used by the Navy currently.

"It was a device we used to verify the temperature of a dosimeter reader, as the device didn't have capabilities to do that," he said.

Images of the gold nanoparticle loaded PLA. (Photo provided by Dr. Luis Benevides)



Carderock's Unique Capabilities Help Assess Damage to Sunken Lexington

By Todd A. Hurley, NSWC Carderock Division Public Affairs

USS Lexington (CV 2), often called “Lady Lex,” was commissioned at Quincy, Massachusetts, in December 1927, and was the second aircraft carrier to be commissioned by the United States Navy. Primarily operating in the Pacific, Lady Lex took part in fleet maneuvers in the Caribbean, the Hawaiian Islands and off the Panama Canal.

The burning and sinking of the USS Lexington (CV 2), after her crew abandoned ship during the Battle of Coral Sea, May 8, 1942. (U.S. Navy photo provided by Vulcan Inc.)

In 1942, she participated in the Battle of the Coral Sea. After her aircraft took part in sinking the Japanese aircraft carrier Shokaku and raided the aircraft carriers Shokaku and Zuikaku, the Japanese retaliated with aircraft attacks. USS Lexington was hit with two torpedoes and three aerial bombs, two of which were Type 91 aerial torpedoes—an

armor-piercing projectile used by the Imperial Japanese Navy and specifically developed for attacks on ships in shallow harbors.

The attack lasted eight minutes and resulted in substantial damage at four different locations of the ship. The ship's crew was able to recover from the assault and had the ship on an even keel with all fires extinguished within an hour. However, due to a large internal gasoline explosion 75 minutes after the attacks, she was abandoned and later scuttled by USS Phelps (DD-218), causing her to be the first U.S. Navy aircraft carrier lost in World War II.

She remained undiscovered for nearly 76 years.

It was not until March 4, 2018, that she was discovered approximately two miles under the sea by the exploration team Vulcan Inc., while aboard the Research Vessel (R/V) Petrel. Vulcan Inc. was founded by Microsoft co-founder Paul Allen.

“Before he passed away, Paul Allen gave the

Vulcan an almost infinite amount of money to go out and look for sunken war ships by using Unmanned Underwater Vehicles equipped with sonar,” Carderock's Howard “Howie” Draisen said, the Branch Head of the Hull Response and Protection Branch. “They were also the team responsible for finding USS Indianapolis (CA 35), among other ships.”

The Vulcan team then provided the Naval History Heritage Command's (NHHC) Underwater Archaeology Branch (UAB) with USS Lexington wreck site video footage and side-scan sonar data captured using remote operated vehicles. NHHC is located at the Washington Navy Yard in Washington, D.C., and is responsible for the preservation, analysis and dissemination of U.S. naval history, which includes managing the Navy's sunken military crafts and ensuring they remain undisturbed.

In the summer of 2018, Kervin Michaud, a

Continued on next page

A Grumman F4F-3 Wildcat with an insignia of “Felix the Cat” painted on it, discovered at the wreck site of the USS Lexington (CV 2). (U.S. Navy photo provided by Vulcan Inc.)

The burning and sinking of the USS Lexington (CV 2), after her crew abandoned ship during the Battle of Coral Sea, May 8, 1942. (U.S. Navy photo provided by Vulcan Inc.)



HAPPENINGS

AT CARDEROCK



A 5-inch gun on the USS Lexington (CV 2) as it is seen at the bottom of the Coral Sea, off the coast of Australia. (U.S. Navy provided by Vulcan Inc.)

Continuation from previous page

former Carderock structural engineer in the Hull Response and Protection Branch, received a nearly 10-month Navy Innovative Science and Engineering (NISE) workforce development opportunity to partner with the NHHHC to evaluate the Vulcan data and historical records to provide expertise in weapons-effects damage assessment.

“This seemed like a great opportunity to go down and help NHHHC – it was incredible to learn what happened to the ship and learn how the Sailors reacted during the attack,” Michaud said. “Through better understanding the vessel’s final moments, the study aimed to provide vital insight to better protect today’s Navy ships against weapon threats.”

The primary portion of Michaud’s work consisted of gathering data such as battle

damage reports, as well as going into the archives to get drawings and video footage of USS Lexington to better understand which part of the ship he was looking at and to verify the reported damage to the ship and how it split apart. His work also allowed him to look at other shipwrecks to see what happened to them, as well as what could have happened.

When discovered, USS Lexington was found to be separated into multiple sections along an underwater ridgeline spanning 550 yards: the bow and stern rest across from each other, the main hull section sits upright on the seabed and the bridge rests by itself in between these broken sections.

“The damage to the bow and stern sections of USS Lexington are severe and difficult to assess,” Michaud said. “The main hull section spans at least 400 feet and is split along the centerline of the ship, with the starboard end laying on the sea floor and the port side exposed in the water column.”

Due to his data collecting and research, Michaud found that what was originally thought to be the cause of the separation of the ship might not be the case.

“As the only reported internal explosion occurred at the General Workshop (A-312E) and historical video footage of USS Lexington after the explosion in this area – but before the ship was scuttled – does not show similar damage, this damage almost certainly resulted from the large successive explosions that occurred following the scuttling,” he said. “These final explosions likely contributed to the separation of the bow and main hull sections, as the main hull section is resting

hundreds of meters away from the bow and aft sections of the vessel.”

Interestingly, at the surprise of the Vulcan team, USS Lexington was not the only wreck found at the site. They also discovered several aircraft, one of which was the Grumman F4F-3 Wildcat with an insignia of “Felix the Cat” painted on it.

In the past, the Hull Response and Protection Branch had partnered with the UAB to investigate the sinking of other historical vessels, which provided Carderock with shipwreck data.

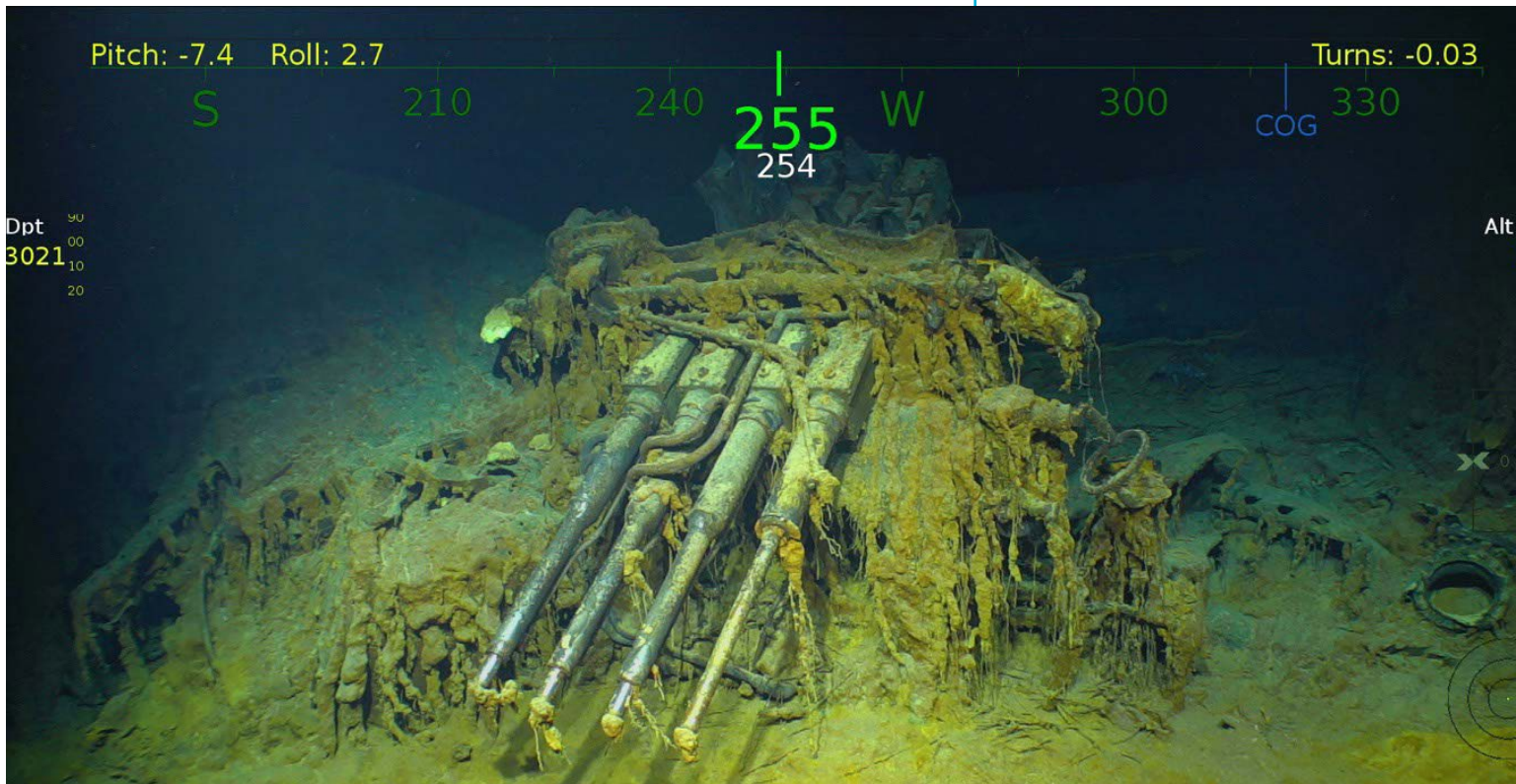
Apart from USS Lexington and USS Indianapolis, the Vulcan team has been responsible for discovering wreckages of USS Cooper (DD-695), USS Hornet (CV-8), USS Wasp (CV-7) and USS Ward (DD-139).

Michaud, a Philadelphia native, had been a Carderock employee for nearly 10 years before transferring to NSWC Philadelphia Division in August 2020. He works as a structural engineer in Philadelphia Division’s Ship Systems Hardening Branch.

“It was awesome to receive the opportunity to partner with the NHHHC and to understand through the lens of the Sailors what happened to USS Lexington,” he said.

The USS Lexington (CV 2) nameplate. (U.S. Navy provided by Vulcan Inc.)

An anti-aircraft gun aboard the USS Lexington (CV 2). (U.S. Navy provided by Vulcan Inc.)



A group of nine people, including crew members and officials, are standing in front of a large model of the LSV-2 Cutthroat submarine. The group consists of five women and four men. One man on the right is in a formal Navy uniform. The background shows the large, white, cylindrical hull of the submarine model, with a sign above it that reads "LSV-2 CUTTHRO". The setting appears to be an industrial or research facility.

USS Idaho (SSN 799) Tours Carderock's Acoustic Research Detachment

By Todd A. Hurley, NSWC Carderock Division Public Affairs

Crewmembers of the USS Idaho (SSN 799), as well as the ship's Commissioning Committee, toured Naval Surface Warfare Center, Carderock Division's Acoustic Research Detachment (ARD) in Bayview, Idaho, on Oct. 5, 2021.

USS Idaho, the fifth Navy vessel named after the state, will be a leading-edge Virginia-class nuclear-powered fast attack submarine, and is scheduled to be commissioned into the fleet in the summer of 2023.

The visit and tour of Carderock's ARD was part of the USS Idaho Crew's North Idaho tour. This tour was coordinated by its Commissioning Committee as part of their efforts to create a bond

between the people of Idaho and the Sailors of the submarine that will last throughout the life of the ship and beyond. Additionally, the visit highlighted the contributions of Carderock's ARD towards the design of USS Idaho, a Virginia-class Block IV design.

The tour consisted of the ARD's facilities and models, including the Large Scale Vehicle (LSV)-2, the largest unmanned submarine in existence, as well as a model of USS Idaho. The tour was provided by Carderock's Steve Finley, the ARD Test Operations Manager, and John Becker, the ARD LSV Chief Engineer, of the command's Lake Pend Oreille Test and Engineering Branch. A technical briefing was provided

HAPPENINGS

AT CARDEROCK

From L to R: Connie McGee, ETN2 Enrique Caballero, David Miskimens, Sue Thilo, Terry Stackley (SSN 799 Sponsor), Henry Netzer, John Becker, CDR Nicholas Meyers (Command Officer USS IDAHO), LCDR Trevor Ellison, Stan Handley, MMN2 Joshua Jordan, Don Curry, STSC Mark Phelps, Honorable Dirk Kempthorne, Alan Griffiths (U.S. Navy photo by Seth Lambrecht, Code 728.)

by Tom Pfeifer, ARD's Lead Analyst in the Radiated Noise and Decomposition Branch.

During the tour, Cmd. Nicholas Meyers, the Commanding Officer of USS Idaho, presented a 1:192 model of USS Idaho to Alan Griffiths, the ARD Site Director, who accepted on behalf of Carderock's Commanding Officer CAPT Todd E. Hutchison. Meyers also presented a USS Idaho command coin to the entire Carderock ARD team in recognition of their support in the design of the ship.

The visit also consisted of a brief boat tour of Lake Pend Oreille, where

Terry Stackley, the sponsor of USS Idaho, took a sample of water from the lake with intentions of using it during the christening of the ship.

Present for the visit were five USS Idaho crewmembers, including Meyers. Also present were Stackley and the Honorable Dirk Kempthorne, a former Governor of Idaho, and the Chairman of the USS Idaho Commissioning Committee Advisory Board, as well as six members of the USS Idaho Commissioning Committee, including Capt. Henry Netzer, U.S. Navy retired, North Idaho Regional Chair.

HAPPENINGS

AT CARDEROCK



NSWC Carderock Partners with TCG to Develop and Advance the MASSMELT Technology and Next Gen PWP

By Todd A. Hurley, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division has entered a Cooperative Research and Development Agreement (CRADA) with the Thermal Compaction Group (TCG). This CRADA, signed by Carderock's Commanding Officer CAPT Todd E. Hutchison on April 29, will leverage TCG's intellectual property — U.S. patent 9,956,736 B2 — as well as lessons learned and technical capability with their MASSMELT general waste processor to support development of a continuous feed plastics waste processor (PWP) that meets U.S. Navy shipboard requirements.

By using a sophisticated heating and cooling system, the MASSMELT machine is able to process compressible solid waste into a dense, extruded log. It exploits the plastic and waxes present in a typical waste stream to encapsulate the remainder of the waste material as well as eliminating fluids to reduce its weight. This reduces total waste volume at an improved processing rate, compared to existing solid waste management systems.

"In 2009, our original team lead had come

across TCG and their MASSMELT product, but it didn't seem worthwhile back then," Carderock's Peter Cheung said, an engineer in the Environmental Engineering, Science and Technology Branch, and Carderock's Principal Investigator in this CRADA. "But, now their technology has improved. We are always looking for ways to improve and/or add new capabilities to existing processes, so when this idea was brought up again about a year and a half ago, we decided to visit TCG again to conduct demonstration tests. Based on those tests, we determined it could be a potential solution for future Navy solid waste management requirements, so Naval Sea Systems Command approved the purchase of the MASSMELT for additional research, development and testing at Carderock."

Should lab evaluations demonstrate that the MASSMELT technology is beneficial to Navy's next-generation (NextGen) PWP solution, the CRADA would allow for Carderock to develop a prototype using this technology, where the engineering drawings and process software are Navy-owned and content-controlled, and also advance the state-of-the-art of the MASSMELT technology for potential commercial applications.

"We are currently in the process of testing the current state of the MASSMELT system," Cheung said. "From this evaluation and testing, we hope to come up with a better system, one that is optimized to meet all the Navy requirements. In order to do that, we need to make modifications and changes. We are hoping to have our finished product within two years."

With the signing of this CRADA, Carderock and TCG have agreed to collaborate on a handful of different tasks, as well as perform tasks individually.

In collaboration, Carderock and TCG will co-develop initial test plans, share knowledge

about the MASSMELT and NextGen PWP, analyze test results and identify engineering solutions to issues and improve risk mitigation, identify improvements to system productivity, operability, maintainability and reliability of the design. They will also produce a final product that will meet the Navy's fleet needs. This final product can potentially be shared with the North Atlantic Treaty Organization and other ally foreign navies.

"TCG is a growing company, so this CRADA is a great win for them, as well as for us," Cheung said. "We get to use their product to create our own Navy product, and they get the opportunity to say they worked on this process with the U.S. Navy, as well as having the right to manufacture and sell this improved version to the Navy and other customers."

Individually, Carderock has agreed to perform several tasks under this CRADA. Among these tasks are a laboratory evaluation using the TCG prototype, MASSMELT, as well as modifying the MASSMELT to meet U.S. Navy requirements, and sharing with TCG all subject data produced in assessing the TCG prototype.

As for TCG, they have agreed to perform six tasks. Among these are providing Carderock with all available MASSMELT technical manual(s), installations drawings, training materials and software, permit Carderock to modify MASSMELT, as required, to meet U.S. Navy requirements and to provide Carderock with technical support and knowhow regarding the TCG prototype MASSMELT.

"With the CRADA in place, we can come up with an improved design that both Navy and TCG will own, while allowing TCG to keep their original design, and give them manufacturing and selling rights to the Navy and other potential customers," Cheung said. "It's a win-win."

CAPT Todd E. Hutchison signs a Cooperative Research and Development Agreement between Naval Surface Warfare Center, Carderock Division and Thermal Compaction Group on April 29, 2021. Behind Hutchison is Carderock's Patrick Long, the Technical Area Lead for Solid Waste in the Environmental Engineering, Science and Technology, and Peter Mech, a representative from Naval Sea Systems Command's program office for Ship Integrity and Performance Engineering (Solid Waste and Hazardous Material Management) (NAVSEA 05P5). (U.S. Navy photo by Harry Friedman)

STEM After School Provides Students Chance to Fly with Help from NSWC Carderock

By Edwin Hernandez, NSWC Carderock Division Public Affairs



What. A. Year. More than 21 months ago, news about the COVID-19 outbreak forced Montgomery County Public Schools (MCPS) to close their doors and switch to virtual learning. The transition has been hard on many, but most of all on the students.

As if keeping students' attention wasn't already hard enough, the virtual learning platform adopted by MCPS: Zoom, allowed middle school and high school students to turn their camera function off. For a teacher, it might have made it more challenging to keep the students interested and focused on the lesson plan. So, how exactly do you keep students engaged throughout a pandemic?

One way is to provide students the opportunity to do some hands-on Science, Technology, Engineering and Mathematics (STEM) activities. Technology Teacher John Lee and Douglas Griggs, a naval architect and Naval Surface Warfare Center, Carderock Division's Hydrodynamics Trial Director, have run The Maryland Marauding Mustangs, an after-school STEM program at Earle B. Wood Middle School, in Rockville, Maryland, for several years.

The club, sponsored by the Flying Aces Club and the National Free Flight Society, focuses on teaching students to build and fly rubber-powered, free-flight airplanes. This year, the after-school club received support from Carderock's STEM and Outreach program, which provided Javelin flyer model kits, tools and materials that Griggs and Lee delivered to each student's home.

"For the most part, I just donated the materials myself, but with COVID, I needed to get each student a full tool kit to build independently," Griggs said. "The STEM and Outreach program, through Charlotte George [director], stepped up."

Since January, the Mustangs have been meeting and building over Zoom, preparing for their International Postal Contest. The club came together in person for the first time

Earle B. Wood Middle School technology teacher John Lee and his daughter prepare to fly a rubber-powered, free-flight airplane at Davis Airfield in Laytonsville, Md., on April 25, 2021. The after school STEM club, also known as the Marauding Mustangs, were competing in this year's International Postal Contest. (Photo provided by Charlotte George)

“For the most part, I just donated the materials myself, but with COVID, I needed to get each student a full tool kit to build independently. The STEM and Outreach program, through Charlotte George [director], stepped up.”

this year on April 25, at Davis Airfield in Laytonsville, Maryland.

"We had nine official members with a bunch more siblings, parents and even a dog join us," Lee said. "It was clear that every kid, students and siblings, had at least one memorable flight, and most had quite a few."

While the students were excited and eager to test their airplanes, Griggs was standing by ready to repair and assist damaged parts. The students had a wise mentor in Griggs with more than 20 years of experience in building and flying rubber-powered, traditional free-flight model airplanes.

"Mr. Griggs didn't see as much of the activity on the field as he'd have liked because he was frantically repairing as fast as the kids could break stuff," Lee said. "But he did get a chance to help a student put up a 27-second javelin flight. Ryan [the student] had a longer flight earlier, but that was without landing gear, which was required for the official flights. We strapped the landing gear from Mr. Griggs javelin onto Ryan's plane for some legit official flights."

Griggs did, however, have an impressive flight himself.

"Mr. Griggs snuck a couple flights of his javelin in too, achieving a respectable 45 seconds in 10-15 mph winds," Lee said.

Although the weather hindered the flights significantly, Griggs said there were other clubs that had a similar outcome. As a result, the event organizers are planning to redo the contest in late May, running it for nine days instead of two. Overall, Griggs was upbeat about the whole event and said he felt proud of his students.

"Despite the weather, this may have been the best day of flying ever," he said. "Seeing the families of our students safely and thoroughly enjoying each other – and the magic of free flight, was all I could ask. The iffy weather let up just enough for everyone to fly and run around and just generally have happy pandemonium."

Griggs's priority has always been to teach students to use their hands and brain together to create things from raw materials. According to Griggs, some of these traditional assembly skills are lost to video games, drones and foam planes. He and Lee are motivating students to read and interpret drawing, and teaching them to transform two-dimensional information into three-dimensional objects.

"We want them to learn how to fit, adjust, assemble, operate and repair things that others might just throw away," Griggs said. "The motto of the Maryland Marauding Mustangs brazenly steals MIT's motto, 'Mens et Manos', or 'mind to hand' and adds a bit: 'Mens et manos ad Caelum', or 'mind to hand to sky.' These skills apply far beyond simple model building and they are learning in a fun and engaging activity."

In the past 10 years of running the program, Griggs said there are two moments that stick out.

"The first was a couple years ago when I showed up at the school early in the year to discuss when we would start the program back up with Mr. Lee, and one of the students from the previous year was in the room," he said. "When he saw me, his whole face lit up and he excitedly asked, 'Are we doing planes today?' His joy was infectious. The second was the flying session we just had. When the cars started rolling in, and we ended up with almost every student along with younger and older siblings and parents, I was stunned and thrilled. The joy and magic of flight that I felt myself and that I felt from my students and their families was one of the best experiences of my life."

NSWC Carderock Promotes Navy STEM in the Maryland Engineering Challenges

By Edwin Hernandez, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division supported this year's Maryland Engineering Challenges (MEC) competition at the Baltimore Museum of Industry on April 24. The MEC mission, according to the event's website, is to introduce students in grades 1 to 12 to the role of engineers in today's society and connect what students learn in school with real-world engineering concepts.

Carderock's Doug Griggs, a naval architect and the Hydrodynamics Trial Director, was the event coordinator for the Cargo Ship Competition, which tasked high school students with designing and demonstrating a bulk carrier cargo to navigate and deliver containerized cargo over a water course with narrow channels at each end of the transit.

Carderock's Science, Technology, Engineering and Mathematic (STEM) and Outreach Program Director, Charlotte George, supported the students by providing hardware and electronics for the model cargo ships. Operating through a pandemic, however, meant that some rules governing the event would undoubtedly change.

"Some challenge parameters were modified this year to make the ships smaller and more practical for a student to build individually," Griggs said. "A navigational hazard was also added, with a cross bar representing a shallow sandbar only a half an inch deeper than the limiting draft of two inches."

Each team was evaluated on five separate components, including a written report with drawings, an oral report, design and fabrication, reliability and performance demonstration. The cargo ships were tested and demonstrated in Baltimore's Inner Harbor. Rockbridge Academy's Michael Grube was the winner of this year's contest.

"Despite considerable uncertainty about the ability to hold this event in the light of pandemic restrictions, two teams persevered and both produced cargo ships that successfully completed the course," Griggs said.



“Despite considerable uncertainty about the ability to hold this event in the light of pandemic restrictions, two teams persevered and both produced cargo ships that successfully completed the course.”

Michael Grube (left), with his little brother, holds the winning cargo ship next to Connor Merrill and Kendall Marx's strong second place cargo ship on the right at the Maryland Engineering Challenges competition on April 24, 2021, in Baltimore. (U.S. Navy photo provided by Douglas Griggs.)

and Kendall Marx and Connor Merrill, who came in a strong second place with their ship, earned the \$200 second place scholarship."

Another part of the event's mission with this STEM challenge was to help students develop comprehension and problem-solving skills; encourage teamwork and self-confidence; and promote meaningful mentor relationships with engineering professionals.

Griggs added that while both teams enjoyed the competition, Kendall Marx vowed to return next year to claim victory.

"Michael won the event decisively with a very detailed written and oral report, as well as stellar performance on-water," Griggs said. "The Propeller Club of Baltimore donated a \$300 scholarship to the first place winner,

Carderock Interns Participate in Navy's First Soft Robotics STEM Initiative

By Courtney Jones, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division high school interns completed a summer program assignment to learn about, evaluate and improve SeaJelly, a free-swimming biomimetic underwater robot. This project was one of six projects that high school interns worked on this summer, as participants in the virtual Science and Engineering Apprenticeship Program (SEAP), and was sponsored by the command and the Office of Naval Research.

SeaJelly is Carderock's newest homegrown science, technology, engineering and mathematics (STEM) educational platform, created by Jennifer Nunes, a mechanical engineer in Carderock's Maritime Systems Hydromechanics Branch. It was designed for high school students to learn about fabrication, mechanical design, underwater electronics, autonomous programming and robot development.

The original concept came from Nunes' master's thesis at Florida Atlantic University in Boca Raton, where she earned her degree in mechanical engineering. Her original research prototype, "JenniFish," focused on soft robotics production and characterization control algorithms. JenniFish was used as the foundation for SeaJelly, tailoring it towards a hands-on STEM initiative suitable for high-schools students.

The SeaJelly platform serves as a starter kit to build your own underwater robot, and encourages students to identify how the robot can be used in the real world, including how to modify and improve the robot for specific purposes.

This past summer, SEAP interns were sent a fully built SeaJelly robot at the beginning of their internship. Nunes acted as their mentor throughout the summer. She provided a project guide offering an in-depth overview of the robots, whose soft, silicone actuators mimic the movement of a jellyfish underwater. The guide explained to the students the mechanics, technology and operation of the SeaJelly robots. The interns also received a base code that didn't have all its functionality. They determined how to modify it by either adding extra sensors or making the sensors' feedback more beneficial to the system.

This summer's project wasn't so much about building the devices, but rather about learning new concepts, gaining hands-on experience and encouraging creativity. The interns ran their own experimental testing, made prototype modifications and implemented new controls —all virtually.

While the SEAP internship was completed remotely, the high school students did have the chance to visit Carderock's West Bethesda

base and test their robots in person on August 4.

"The focus of today is getting it in the water and saying, 'Ok, if I put pool noodles up here and I do magnets on the bottom, does it work?'" Nunes said.

The ultimate goal for the in-person experiment was to test the robots while looking into ballast conditions and how they affect the vehicles' dynamics and maneuverability. Since the students weren't able to make their own SeaJelly, Nunes also used the in-person visit to demonstrate how the silicone pieces are made.

"Soft robotics, in general, is a growing field, and we're seeing some really cool applications," Nunes said. "I think that you could do some modifications on the platform to make changes. There are a variety of different things it could be used for — potentially water quality monitoring. Certainly, right now, it is hands-on learning."

Nunes said she enjoyed working with the students on the assignment.

"It's been kind of fun and creative in the fact that I didn't necessarily prescribe exactly what they had to do, so there's no answer key, which is fine. But also, they got to really pursue what interested them," she said.

Moving forward, Nunes and Carderock's STEM and Outreach Program Director, Charlotte George, will take feedback collected from the interns to improve the SeaJelly project. Soft robotics technology is an emerging field, and the SeaJelly platform is modifiable for practical, real-world settings.

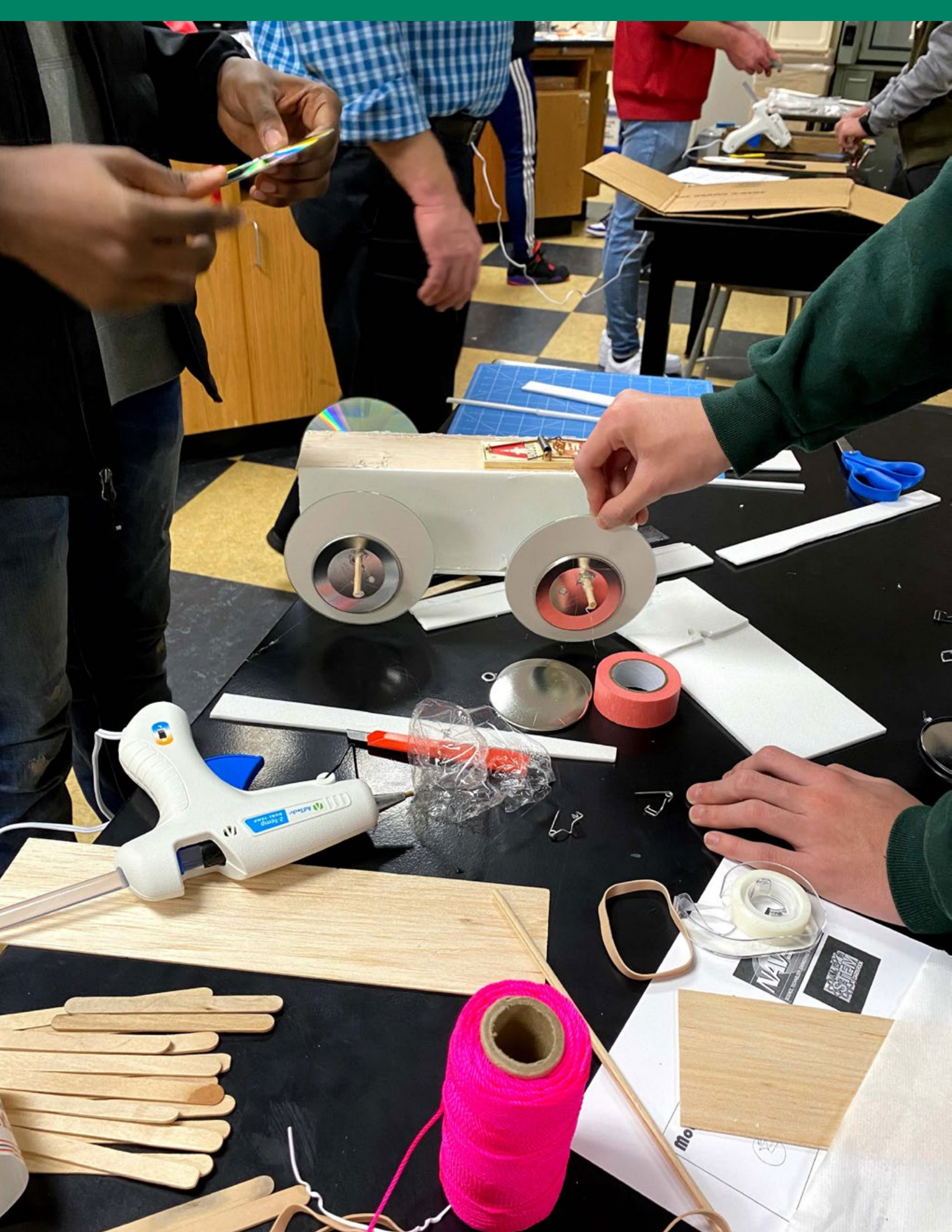
"Robotics is a common theme in Naval STEM," George said. "I think that SeaJelly is unique because it incorporates a lot of really cool hands-on fabrication techniques that some of our other STEM programs don't touch. SeaJelly is a fun and engaging way for students to build a novel underwater robot, and identify creative real-world applications."



SEAP Intern Ian Clark pours silicone mix in a SeaJelly mold while on tour at Carderock in West Bethesda, Md., on Aug. 4, 2021. In each piece of the material is what Nunes calls a "void," which each have chambers inside. Four pumps and four actuators pull in water and fill the tentacle-like arms, allowing the vehicles to swim underwater. (U.S. Navy photo by Edwin Hernandez)



SEAP Intern Darwin Otchere assembling materials for a SeaJelly launch at Carderock in West Bethesda, Md., on Aug. 4, 2021. (U.S. Navy photo by Charlotte George.)



Carderock Provides STEM Outreach with Covenant Life School

By NSWC Carderock Division Public Affairs

Although opportunities for in-person programing have been rare since the onset of the COVID-19 pandemic, the Naval Surface Warfare Center, Carderock Division Science, Technology, Engineering and Mathematics (STEM) and Outreach team was recently able to provide an engineering mini-course for students at the Covenant Life School (CLS) in Gaithersburg, Maryland. Bill Merryman, Carderock engineer and customer advocate in the Office of Customer Advocacy, volunteered to lead a two-day engineering course to expose students to engineering careers and provide them hands-on experience with the engineering design process.

“The teachers bring in folks that would provide outside classes that are not typical to the classroom environment, to help them understand what it’s like to have a career. I was asked to help run a course on engineering, so I volunteered,” Merryman said, a CLS parent. “This is the second year that I’ve been involved.”

He enlisted Suzy Otto, Carderock’s current Albert Einstein Distinguished Educator Fellow, as a lesson planner and co-teacher for the event.

“I am a teacher at the Paris High School in Paris, Missouri,” Otto said. “The whole idea is to provide a two-way street between teachers and the DOD. It allows the opportunity to provide a teacher’s voice and insight, while also allowing the teacher to learn along the way.”

This engineering course was offered as part of CLS’s annual J-Term, a two-week period in January upon return from the holiday break that is reserved for exploration and

enrichment courses, activities and internships. This year, due to the COVID-19 restrictions, CLS scaled back to only a one-week in-classroom experience during J-Term.

Fifteen students from grades 9-12 participated in the engineering course. They were first challenged to consider how the STEM disciplines apply in their everyday lives, in objects as familiar as a pen and as complicated as a Navy destroyer.

“The students could choose from about 10-15 different classes,” Merryman said. “We had 15 students. Suzy and Charlotte George came up with the project ideas while I carried them out and briefed the students on what Carderock is about. Due to the pandemic, we did our best to follow CDC guidelines and to have the students separated enough — we did the best we could and ended up having extreme success.”

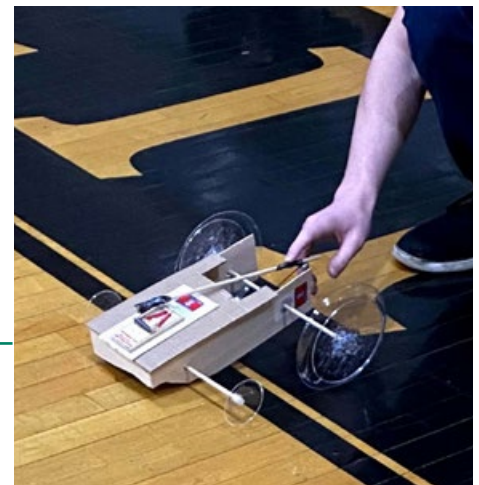
A wide variety of engineering disciplines were discussed with the students, with Merryman and Otto showcasing their own engineering experiences and educational and career paths. Students next learned about and applied the engineering design cycle to build a tower from marshmallows and toothpicks. This simple activity introduced engineering concepts like prototyping and budget constraints, in addition to strategies for building a structure that balanced height with strength.

“The whole point of the course is to reach out to the students and to help them understand the pros of being an engineer and to show them that engineering is a good career path if they like math or science,” Merryman said. “We gave them projects they can work on to

help stimulate them and give them hands on stuff to build or design.

The final activity for the course involved the construction of a mousetrap powered vehicle. Each team designed their prototype car body, wheels and axles, and powering mechanism independently, with little prescribed instruction. This gave the students opportunities to problem solve and be creative as they cut, tied and glued together their parts from simple, often recycled, materials. They applied scientific concepts such as energy conversion, torque, rotational motion and the mechanical advantage of a simple machine as they worked. Many groups found it challenging to move from an on-paper design to a working model with material and time constraints, gaining insight into some of the struggles that professional engineers also face. In the end, some groups were more successful than others, but all the students agreed that they had learned something and were confident that they would be successful.

“The whole idea is to get children interested in STEM while they are young, so they remain interested when they are older,” Otto said. “I think it turned out to be a great success. It certainly helped me learn — I didn’t know anything about Carderock before this, so I am forever grateful for this opportunity.”



The students experiment with different materials such as hot glue guns, yarn, CD's and recycled plastics to create the perfect mousetrap powered vehicle. Photo taken at Covenant Life School in Gaithersburg, Md., in January 2021. (U.S. Navy photo provided by Charlotte George)

The final activity, or project, for the course was to build a mousetrap powered vehicle using mostly recycled materials. Here is an up-close view of one student's final product. Photo taken at CLS in Gaithersburg, Md., in January 2021. (U.S. Navy photo provided by Charlotte George)

INVESTING

IN OUR FUTURE



Carderock Einstein Fellows Visit STEM Wonderland

By Edwin Hernandez, NSWC Carderock Division Public Affairs

On May 11, three Department of Defense (DoD) Albert Einstein Distinguished Educator Fellows (AEF) visited the Commonwealth Charter Academy (CCA) and two cutting-edge robotics facilities in Pittsburgh, Pennsylvania. The objective of the trip was to gather information about science, technology, engineering and mathematics (STEM) educational activities, outreach and workforce development.

Students participate in the BotsIQ tournament, a robotics competition for high school students, at the TechWorks facility in Pittsburgh, Pa., on May 11, 2021. Teams competed in an enclosed plexi-glass arena. (Photo provided by Charlotte George)

An inside view of the TechWorks sign inside the Commonwealth Charter Academy (CCA) in Pittsburgh, Pa. (U.S. Navy photo provided by Charlotte George)

The Einstein Fellows: Laura Larkin; Suzy Otto; and Mike Vargas, all of whom are accomplished educators, began their tour at TechWorks with former Naval Surface Warfare Center, Carderock Division AEF, Debbie Reynolds. Reynolds, who is now the director at TechWorks at CCA, a center that focuses on STEM education and career exploration in Pittsburgh, was the first Einstein fellow to do her fellowship at a DoD STEM organization. She and Charlotte George, Carderock's STEM and Outreach Program Director, played a pivotal role in paving the way for



more Einstein fellows to complete their assignment within the DoD STEM workforce.

“Debbie was part of the first ever Einstein fellow at Carderock and is an active alum in the Albert Einstein Fellowship Program,” George said. “I’ve kept in touch with her since her fellowship at Carderock ended last year. She invited the new fellows to visit her facility much earlier in the program, but a trip was not seriously considered until some COVID restrictions were lifted to allow for travel. All of the facilities on the tour had a tie to one of the fellows’ work for the DoD.”

Continued on next page



Debbie Reynolds, a former Naval Surface Warfare Center, Carderock Division Albert Einstein Distinguished Educator Fellow (AEF), shows this year's AEFs Suzy Otto, Mike Vargas and Laura Larkin the Mobile Aquaponics Lab in Pittsburgh, Pa., on May 11, 2021. The Mobile Aquaponics Lab contained plants, an aquarium and a grow wall. (U.S. Navy photo provided by Charlotte George)



Continuation from previous page

Although Larkin, Otto and Vargas are Carderock fellows, they have been detailed to other DoD STEM organizations to learn and support different work. Larkin is assigned to support DoD STEM office. Vargas currently supports the Office of the Under Secretary of Defense in Virginia, as well as Air Force STEM. Otto is the only fellow working directly at the command full-time. Sometimes, however, Larkin and Vargas will come back to support STEM activities for Carderock. They work together as a DoD cohort to support multiple programs across the DoD.

The fellows began their tour by visiting CCA, a K-12 online charter school with 19,000 students across the Commonwealth, and learned about the cyber school's model for remote teaching.

"They're a large statewide institution," Larkin said. "They have Family Service Centers located in various cities in Pennsylvania. TechWorks has an amazing assortment of STEM opportunities. So, although most of their teachers are teaching remotely because of the Pandemic, in a normal time, they would be in a building teaching their lessons online."

A crucial component of CCA's mission is the CCAWorks Initiative. CCA has examined the industry sectors across the state and created three state of the art facilities designed to provide their students with real world,

hands-on learning experiences that can be directly translated into career fields. At the headquarters in Harrisburg, Pennsylvania, they built AgWorks, which is the largest K-12 aquaponics facility in the country. Since Pittsburgh is the booming technology hub of the state, TechWorks was placed there, and CCA is currently building MedWorks, which will be located outside of Philadelphia.

After touring the teacher area of the Homestead facility, the next stop for the fellows was to spend time in TechWorks, which had ample space – boasting about 7,000 square feet – and included multiple 3-D resin printers; two Doosan robotic arms; Vex and Lego Robotics, Hummingbirds and Micro: bits; Spheros; a Boston Dynamics robot dog; immersive technologies, including a virtual reality play space; a large open area for robotics tournaments; and a drone course. The perfect "STEM Wonderland."

While at TechWorks, the fellows were able to play with the unique, fun equipment.

"We were able to put on the headsets and try out the virtual reality applications, fly drones and I'm sure if we stayed longer, Debbie would have been happy to have us 3-D print something," Larkin said. "When we were



Suzy Otto, Mike Vargas and Laura Larkin, Carderock's Albert Einstein Distinguished Educator Fellows, take a picture with a Boston Dynamics robot dog at the TechWorks facility in Pittsburgh, Pa., on May 11, 2021.(U.S. Navy photo provided by Charlotte George)

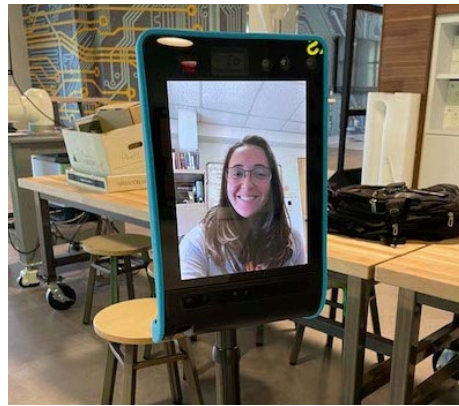
INVESTING IN OUR FUTURE

Debbie Reynolds, the Director at the TechWorks facility in Pittsburgh, Pa., flies a drone through an obstacle course with Suzy Otto, one of Carderock's Albert Einstein Distinguished Educator Fellows, on May 11, 2021. (U.S. Navy photo provided by Charlotte George)

there, there was a robotics competition happening. There were robots that were trying to destroy each other.”

That robotics competition was the BotsIQ tournament, a high school robotics competition where teams build 15-pound bots and compete in an enclosed plexi-glass arena similar to the BattleBots competition. The fellows also had the chance to spectate the Remake Learning Days STREAM Showcase, which featured several local tech companies and labs. Among those labs were CCA's mobile aquaponics lab, AquaJack, and a fabrication lab. The former contained an aquarium and grow wall, while the latter displayed laser cutters, 3-D printers and circuit activities.

“The mobile labs can go around the state and show up in a different location so kids can have hands-on STEM experiences,” Larkin said. “The DoD needs scientists and engineers. We need to increase the diversity and interest of students in STEM, and all students deserve to have an exciting STEM experience – hopefully early on. Almost every kid in America gets to play soccer, or is on a softball team often before they are five or six years old, but how many of those students also get an exciting STEM experience?”



Charlotte George, Carderock's STEM and Outreach Program Director, speaks with the Albert Einstein Distinguished Educator Fellows from her office in West Bethesda, Md., on May 11, 2021. (U.S. Navy photo provided by Charlotte George)

She is right. Sports in America is a major interest and the accessibility to participate in sports is easy. However, part of the fellows' objective is to explore how to engage more students in STEM.

“We were blown away by CCA's facilities,” Larkin said. “I think if schools could have this kind of STEM playground, it would inspire students to consider a career in STEM.”

The last stops for the group was the National Robotics Engineering Center (NREC) and the Astrobotics aerospace facility. Otto, Larkin and Vargas said NREC featured a wide variety of robotic research, including deformable wheels, jet paint stripping, self-driving mining and convoys, smart tractors for increased grain harvesting, and a large Mississippi river erosion prevention robot. NREC works closely with government and industry clients to develop robotic technologies from concept to commercialization. The fellows also noted that the NREC had a robust student

outreach program through the Carnegie Mellon Robotics Academy.

At the Astrobotics facility, they were given a tour of the new facilities under construction including the “clean room,” which housed the Peregrine lunar lander, which is scheduled to touch down on lunar surface in mid-late 2021, and a mock-up of the Griffin lander.

The trip was mutually beneficial for the fellows and the Albert Einstein Distinguished Educator Fellowship Program. Otto, Larkin and Vargas were able to learn plenty on their visit to Pittsburgh, including, and perhaps most importantly, networking.

“Overall, it was a great learning experience to take back to the classroom,” Larkin said.

George and Reynolds are trailblazers for the program's expansion into the DoD and have helped establish new opportunities for future cohorts. After a year disrupted by a relentless pandemic, which forced teachers to adjust to a virtual classroom, this year's fellows will have new, fresh ideas for their students.

Though outreach at Carderock has been almost exclusively virtual since March 2020, George said, “The trip was like a breath of fresh air for the fellows. Part of their Fellowship is to explore new STEM initiatives, from a national platform. A trip like this allows them to network, learn about and use new STEM tools, and bring that knowledge back to DoD STEM programming.”



From left: Director of TechWorks Debbie Reynolds and Albert Einstein Distinguished Educator Fellows Laura Larkin, Mike Vargas and Suzy Otto, stand with a robotics device inside the Astrobotics facility in Pittsburgh, Pa., on May 13, 2021. (U.S. Navy photo provided by Charlotte George)

SEAP Interns Visit Carderock for Tour and Celebratory Picnic

By Benjamin A. Morley, NSWC Carderock Division Public Affairs

The Science and Engineering Apprenticeship Program (SEAP) tour and end-of-summer picnic was the latest demonstration of Naval Surface Warfare Center, Carderock Division's commitment to Science, Technology, Engineering and Mathematics (STEM) Education and Outreach. Student interns who participated in this year's SEAP program were provided a tour of the command's labs on Aug. 9, 2021, to see the ways Carderock employees create, experiment and discover for the benefit of the Navy.

The SEAP program places academically talented high school students with interest and ability in STEM as "apprentices" in Department of Defense (DoD) laboratories for eight weeks during the summer. While the Office of Naval Research oversees the SEAP program, the actual work typically takes place in-person at research labs across the country. Due to the ongoing pandemic, Carderock chose to host all SEAP interns virtually this summer. Locally, however, the SEAP program is run by Carderock's STEM and Outreach Program Director Charlotte George and Intern Coordinator Rachel Luu.

"During the eight-week virtual internship, students worked on a variety of projects," George said. "Students were broken into teams, and provided a dedicated team lead to help direct day-to-day tasking for the interns. The interns rotated through several different projects. Each student was assigned a hands-on project for the duration of the program, and two-research projects. All projects had a dedicated mentor to act as their lead subject matter expert and oversee the technical work supporting their project. We had team leads and mentors support from across the command, and we couldn't have done it without them."

Some of those hands-on projects included a LEGO Robotics Mission, Arduino Robot Development and SeaJelly Robot Development. Research project topics included sustainable solution for sea level rise impacts, alternative/future ship powering options and crane integration study for naval vessels. Projects were developed to promote awareness of naval science and technology; to provide opportunities to hone engineering and professional development skills; and to allow creative freedom within the topics.

During the virtual internship, Carderock maintained student interactions with team members and subject matter experts through Zoom. A weekly lectures series, resume reviews and mock interviews were offered to each student. However, one arguably irreplaceable in-person benefit to summer interns is the opportunity to visit world-class research facilities. Nearing the end of their internship, interns were given a tour and end-of-year picnic to showcase some of Carderock's work. It also allowed for the interns to meet in-person for the first time this summer.

The interns started the tour at Carderock's Manufacturing, Knowledge and Education (MAKE) lab, where they were introduced to Carderock's 3D printing and work in developing parts and components. Here, the interns learned of examples where these components were used to replace damaged parts of ships, such as the often-requested wheel with handles.

The next location on the tour was the Maneuvering and Seakeeping (MASK) Basin, which tests how submarines move underwater,





at model size, to gather data on centrifugal force and other variables. Though ocean engineering was the main talking point, interns learned about how Carderock creates testing environments not available anywhere else, such as how ships react to different types of waves.

Another unique facility the interns visited was the command's Wind Tunnel. The interns listened as Aerospace Engineers Eric Silberg (Code 882) and Kevin Kimmel (Code 882) described the functionality of the facility, which measures wind resistance and the impact on sailing ships.

The last stop on the tour was the David Taylor Model Basin (DTMB) Model Shop and Shallow Water Basin. Here, they learned how models are created and why the command

utilizes model-scale tow testing to understand Navy ships and submarines. The basin holds rich history on the origins of Carderock and the namesake of the DTMB, Rear Admiral David Taylor.

At the picnic, some of the interns revealed what projects they were working on.

"With the SEAP program, we did the SeaJelly project, the crane integration project and then the sea level rise project," SEAP Intern Darwin Otchere said.

When asked about their favorite parts of the tour, the Wind Tunnel and MASK were prominent.

The interns also shared their plans for the

Carderock's Commanding Officer Capt. Todd E. Hutchinson (left) finishing off the tour with a closing speech for the SEAP interns at Carderock Park in West Bethesda, Md., on Aug. 9, 2021. The CO congratulated SEAP interns on their commitment to the program and their newly accrued experiences. (U.S. Navy photo by Edwin Hernandez)

future and revealed a deep passion for STEM.

"I'm going to college in a week actually," Nick Lopez-Rivera said. "And then I'm going to study chemical engineering and if all goes well, hopefully, I will do this again next year for college level. Either that or I might join a specific internship aligned with chemical engineering in a pharmaceutical company."

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The Science and Engineering Apprenticeship Program (SEAP) Intern program participants, mentors and interns take a photo together at the Naval Surface Warfare Center, Carderock Division Park in West Bethesda, Md., on Aug. 9, 2021. After the tour, the SEAP interns concluded their internship by having a picnic and playing yard games. (U.S. Navy photo by Edwin Hernandez)

Charlotte George (middle), Carderock's STEM and Outreach Program Director, engages SEAP interns over the David Taylor Model Basin's history in West Bethesda, MD., on Aug. 9, 2021. Zach Miller (left), program mentor and Carderock engineer with the Advanced Capabilities Branch listens on. (U.S. Navy photo by Edwin Hernandez)

Continuation from previous page

Tyler Weeks and Ochere, who are both entering their senior year in high school, plan to enroll in more STEM based courses. The latter, of which, is hoping to become a chemical engineer.

The interns were not the only ones to have a fun time on this tour. One of the mentors and guides, Zach Miller, an engineer in Carderock's Advanced Capabilities Branch, also described what he liked most about the tour.

"Being in-person for the first time this summer was really great," he said. "We've been on Zoom all summer, so for them to get on base for the first time and see the work that is done at Carderock was really the best part."

Before the picnic and games started, Carderock's Commanding Officer CAPT. Todd E. Hutchison had a few words to share.

"I'm completely impressed in each of you, just putting yourselves out there and getting involved in something like this, and the eight weeks of dedication that you showed just in participating in something like this," he said. "I think you'll find that from life experience, not to mention the technical value that you got out of it, it'll really benefit you for years and years to come. You'll probably be grateful for this time. I hope, on behalf of Carderock and Mr. Larry Tarasek the Technical Director, that the experience was fantastic, and that you will leave with great memories. Maybe before long some of you will be back as full-time employees."

Hutchison also mentioned the purpose of the SEAP program and Carderock's involvement in the community.

Two SEAP interns listen intently as Carderock's Aerospace Engineer Eric Silberg describes his work at the Wind Tunnel during a tour of Carderock's facilities in West Bethesda, Md., on Aug. 9, 2021. (U.S. Navy photo by Edwin Hernandez)



"We're committed to STEM and our command does amazing work in that stead," he said "It's really plugging into the

community and investing in the youth and the next generation of people who are going to lead this country in the STEM fields."



Carderock's Educator Fellow Suzy Otto Completes Year-Long Fellowship

By Courtney Jones, NSWC Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division is heading into its third year hosting educator fellows through the Albert Einstein Distinguished Educator Fellowship Program (AEFP). AEFP is an 11-month program, which runs from August through July each year. During this time, each fellow extends their comprehensive classroom expertise to Federal agencies or U.S. Congressional offices to influence national education programs and policy efforts.

Each year, Carderock selects an educator from the program to support Science, Technology, Engineering and Mathematics (STEM) Outreach. The educators help evaluate Carderock STEM efforts and create new naval-relevant STEM activities for students and educators.

In 2020, Suzy Otto accepted an AEFP position and became Carderock's second Educator Fellow. Otto, a seasoned educator, leveraged her position to significantly contribute to Carderock's STEM program and bolster interest in STEM for high school and college students. As her Fellowship ends, she is heading to graduate school at the University of Missouri, and her efforts will now transfer to Carderock's newest fellow, Stephanie Klixbull.

Otto, who has about 30 years of experience in science-related fields, developed an affinity for chemistry and physics in high school. She earned her bachelor's degree in chemical engineering from Missouri University of Science and Technology in Rolla and then spent nine years working in the oil industry as a chemical engineer.

"Toward the end of that career, I had this realization that the very best part of my job was as an engineering supervisor – I was training the new-hire engineers," Otto said. "There was a lightbulb moment like, whoa, maybe this is something I need to do more of. That's when I decided to pursue my teaching certificate and master's degree in science education."

That realization led to her 17-year career as a



physics, chemistry and physical science teacher at Paris R-II High School in Paris, Missouri. After nearly two decades of teaching, Otto came across the opportunity to apply to the fellowship program through a professional development organization and decided it was worth considering.

"I had been named as the Science, Engineering, Technology, Arts and Math (STEAM) coordinator for K-12 programs in my school," Otto said. "My role as a physics and chemistry teacher had already started to take on a little more of a leadership role."

Despite thinking acceptance was a long shot due to her small-town teaching experience, Otto applied for the fellowship. She said, luckily, the position fit her experience to a tee, and she was accepted.

Charlotte George, Carderock's STEM and Outreach Program Director, praised Otto's efforts and credited her multi-faceted career experience for offering a unique lens to the program.

"Suzy is a rural educator with an engineering background, and uniquely qualified to help Carderock STEM programs appeal to a broader community of educators and students," George said. "She really opened our eyes to how our programs were viewed outside

From left: (Front row) Carderock's Deputy Technical Director Steve Ouimette; Albert Einstein Distinguished Educator Fellows Stephanie Klixbull, Laura Larkin and Michael Vargas; Technical Director Larry Tarasek; (Back row) Chief Technology Officer Dr. David Drazen and STEM and Outreach Program Director Charlotte George, usher in a new era of Einstein Fellows by taking a photo together in the rotunda, building two in West Bethesda, Md. The Einstein Fellows were welcomed to Carderock on Sept. 2, 2021. (U.S. Navy photo by Ryan Hanyok)

of our immediate region and how educators need certain resources, depending on their own support systems."

While supporting Carderock, Otto brought fresh perspective to K-12 STEM efforts at Naval Sea Systems Command sites as well as the greater Department of Defense STEM

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INVESTING IN OUR FUTURE



A student participant at the 2021 Sea Air Space Science, Technology, Engineering and Mathematics (STEM) Expo discovers the relationship between pressure and volume using a marshmallow and syringe. This simple yet memorable interaction is one of the activities featured in Naval Surface Warfare Center, Carderock Division's new STEM-In-A-Box kits for educators. Each kit includes a series of experiments and demonstrations to explore and understand core Naval STEM concepts such as density and pressure. (Photo provided by Edwin Hernandez)

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initiatives. Among Otto's contributions to Carderock STEM programs are her mentorship of summer interns and her development of new STEM-in-a-box kits for educators. Each box contains a handful of naval-relevant activities for students.

"With the STEM-in-a-box idea, we want to provide some curated sets of classroom activities that are naval-relevant, so teachers can learn the content behind it," Otto said. "If you've got a resource-limited school, you've got to have very simple materials and easy access for teachers to be able to implement more hands-on activities to hook students' interest and develop their skills."

George said Otto was instrumental in taking what the STEM office conceptualized and producing a physical product they could use to remove barriers for teachers and students with limited access. As a result, there are plans for STEM-in-a-box teacher training during the 2021-2022 academic year.

This summer at Carderock, all internships pivoted to a fully virtual program. Carderock sourced mentors from across the command to work with students via online platforms. Otto worked with high school and college students on a daily basis – serving as a community touchpoint, and ensuring that students from across the country had a familiar point of contact to ask questions and find resources. Otto's influence and comprehensive knowledge have also impacted high school students.

"I helped get these high school students interested in engineering careers, especially from a Carderock viewpoint, to recruit really good employees down the road," Otto said.

Following former fellows Debbie Reynolds and Otto, Stephanie Klixbull is the new AEFPP fellow at Carderock for 2021. Otto and Klixbull agreed that they were excited about the transition.

Klixbull, who has nine years of experience in the classroom, began her career teaching science as a performing educator at the Denver

Museum of Nature and Science in Colorado. She also taught a STEAM class — IDEA Lab — for pre-school through fifth-grade students at Pinewood Preparatory School in Summerville, South Carolina.

In 2018, Klixbull earned the Max E. Lundquest Rising Star STEM Educator Award from the International STEM Education Association for her work in early childhood STEM curriculum. In 2019, the South Carolina Schools Association named her Teacher of the Year.

Within the AEFPP program, Klixbull will focus on STEM outreach and hands-on learning for pre-school and elementary school children.

Klixbull explained her motivation for the fellowship and shared her passion for educating the budding students. She hopes to advocate and spread the word that STEM-related early childhood development learning can be impactful.

"I taught Pre-K through fifth grade STEM and engineering," Klixbull said. "I just loved how hands-on it was and how I could even teach engineering concepts to Pre-K and kindergarten learners. They're very smart, and they get it. I truly think that STEM should be taught in early childhood to develop those fine motor skills and critical thinking."



Carderock's new STEM-In-A-Box kits for educators have been developed for K-2nd, 3rd-5th, middle school and high school educators. Each kit follows a theme, uses easily accessible materials, comes with full documentation for classroom implementation, and aligns to national standards. Shown here is the Density and Buoyancy kit for middle school teachers. (U.S. Navy photo by Eric Anderson)

NASA Astronaut Sends Message to ISR Contestants

By Edwin Hernandez, NSWC Carderock Division Public Affairs

Houston, do you copy? Megan McArthur, a former International Submarine Race (ISR) contestant and now NASA Astronaut, delivered an inspiring message to the 2021 virtual ISR 16 contestants from the International Space Station. Although ISR competitions are usually held in-person and hosted biennially at Naval Surface Warfare Center, Carderock Division in West Bethesda, Maryland, the 2021 edition of the science,

Astronaut Megan McArthur gives a pep talk in a video from the International Space Station to students participating in the 16th International Submarine Races in June 2021. The ISR was held virtually due to concerns stemming from the COVID-19 pandemic. McArthur recently served as the Pilot of the NASA SpaceX Crew-2 mission to the ISS, which launched on April 23, 2021. She had participated in the submarine races as a college student, and credits the experience for her decision to pursue becoming an astronaut. (Photo provided by Kelly Stirling)

technology, engineering and mathematics (STEM) event operated exclusively online due to the COVID-19 pandemic. In her remarks to the teams participating in ISR 16, McArthur encouraged the next generation of STEM professionals to continue chasing their dreams.

“I’m so glad to know that students are still innovating and competing in the International Submarine Races,” McArthur said. “I’m sorry it is not possible for you to be in the water at Carderock this year, but this is still a unique opportunity to learn and grow. It is absolutely true that my participation changed my life.”

At the time of ISR 3, which was the last time the prestigious competition was held in Ft. Lauderdale, Florida, McArthur was nominated by her team to pilot her school’s human-powered submarine. She was selected because she was the only one who could fit in the small, tightly packed space.



“I was the smallest person on the team, so I was assigned the pilot role in our two-person sub,” she said. “I was the only one that could fit into the space leftover after we built the sub around our powerhouse bicyclist.”

One of the most important requirements before piloting a human-powered submarine is to become scuba certified. McArthur admitted, however, that swimming was not her forte.

“As someone who was not a strong swimmer, and a little afraid of the ocean, this was something of a challenge,” she said. “But meeting that challenge helped me grow stronger, and I fell in love with the ocean along the way.”

While winding down her undergraduate studies at the University of California, Los Angeles, McArthur was mainly interested in space exploration, but during her participation in ISR, a new interest in ocean exploration blossomed.

“I was studying aerospace engineering at UCLA, hoping to one day work for NASA and maybe even become an astronaut,” McArthur said. “I really wanted to do space exploration, but knew I wanted to do ocean exploration, too. I met Dr. Kathy Sullivan at

the end-of-the-race barbecue by the beach. She told me, ‘You need to figure out what it is you love doing and then work really hard to be as good as you can be doing that thing.’

“ I’m so glad to know that students are still innovating and competing in the International Submarine Races. I’m sorry it is not possible for you to be in the water at Carderock this year, but this is still a unique opportunity to learn and grow. It is absolutely true that my participation changed my life.”

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She said, ‘Don’t try to guess what NASA will want and pursue something just for that reason. If you don’t love what you’re doing, you’re never going to be good at it. And if you’re not good at it, you’re not going to get selected by NASA.’”

Sullivan’s message – especially as a former NASA astronaut – connected well with McArthur as she was accepted into the NASA astronaut program, eventually fulfilling her dream. McArthur was assigned to STS-125, which was the fifth final Hubble repair mission in May 2009. She was the Mission Specialist/Robotic Arm Operator who had to grab the slowly spinning Hubble, wrestle it into the shuttle bay and fly an astronaut “repairman” around on the end of the robotic arm making repairs.

McArthur always had space exploration on her mind, and her career is a testament to all the hard work, commitment and dedication

“**I am where I am today, because of the human-powered submarine races. In 1993, I was sitting where you are sitting this evening. Had I not been a human-powered submariner, I would not be an astronaut.**”

she had to achieve her goal. ISR, however, connected her with the right professionals.

“I am where I am today, because of the human-powered submarine races,” she said. “In 1993,

I was sitting where you are sitting this evening. Had I not been a human-powered submariner, I would not be an astronaut.”

This STEM competition continues to provide a platform for students to discover and explore their passions. ISR showcases the talents of promising future STEM professionals like McArthur, who concluded her message to contestants with a good piece of advice.

“Through this project, you’re getting a strong foundation in team work and finding innovative solutions to challenges,” she said. “This will serve you well and don’t forget to find that passion. It might take a while, or you might change your mind – and that’s ok. As long as you keep learning, challenging yourself and keep trying new things, you’re on the right path. Don’t forget to share your dreams with the people around you.”

To see the full video, visit the Carderock YouTube site: <https://youtu.be/njm7KguZ90Q>

vISR 16 Concludes; Award Winners Announced

By Edwin Hernandez, NSWC Carderock Division Public Affairs

June 25, 2021, marked the conclusion of the first-ever virtual International Submarine Race (vISR) hosted by the Foundation for Underwater Research (FURE) and the Naval Surface Warfare Center, Carderock Division. The event, which welcomed 12 teams from the United States, United Kingdom and Canada, presented students with several human-powered submarine design challenges.

FURE, who sponsored and managed the event, announced its award winners and runners-up for this year’s vISR. FURE President Charlie Behrle said he wished he could have hosted all teams at Carderock’s David Taylor Model Basin, however, due to the COVID-19 pandemic, it was best to keep everyone at home. While this year’s format was different, students were still able to display their talents and problem-solving capabilities in submarine and hull designs, as well as demonstrate an ability to think on their feet during interactive problem-solving Zoom sessions with FURE judges.

“I want to thank all of you for ‘zooming in’ today,” Behrle said at the online awards

ceremony. “I know I speak for everyone when I say that we would much rather be closing out the races by exiting the water at the David Taylor Model Basin, celebrating our successes with a picnic, and then going to the auditorium for the awards ceremony. I do want to applaud each of you, your hard work and your participation in this year’s virtual race.”

Behrle said one of the biggest challenges this year for the FURE team was shifting gears from an operational “race” event to a more academically-based event.

“FURE’s goal is always to challenge these young men and women as they pursue their dreams in marine sciences and engineering fields,” Behrle said. “I believe FURE met its objective.”

Design work is an iterative exercise that involves making tradeoffs to reach an optimal solution, and the challenge for the teams was learning to perform this design work in the virtual environment.

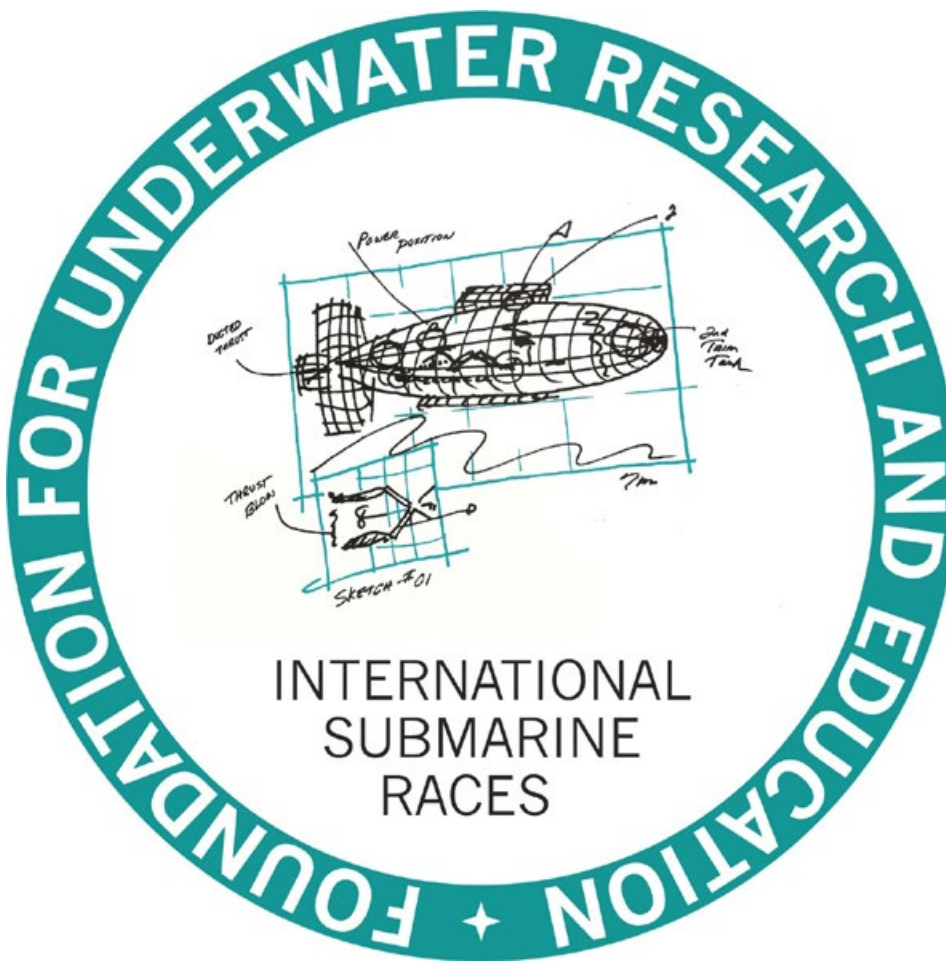
“The team members learned that they needed to be concise in their reasoning for design decisions and convince other team members

that the solution being presented deserved to move forward,” Behrle said. “We all learned new ways of communicating in the virtual world.”

Aside from five design challenges and an operational problem-solving challenge, students also had the chance to participate in webinars, which featured naval divers, experts and engineering professionals. The competition even welcomed a message from a former ISR racer, Megan McArthur, who is now a NASA Astronaut and is currently on the International Space Station.

Carderock’s STEM and Outreach Program Director Charlotte George, who worked closely with FURE leadership during vISR 16, coordinated with some Carderock employees to be judges for this year’s online challenges. One of the Carderock judges was engineer and former ISR participant Jane Louie.

“I’m glad we were able to do it this year,” Louie said. “The judging I was involved in was very report-based. It focused on judging the teams’ technical writing about their designs and problem-solving methods. I don’t think it quite captured everything we would normally



take into account – being able to see visually what they’ve done and then actually being able to talk to the students and gauging them on the lessons they learned.”

Carderock’s Commanding Officer, CAPT. Todd E. Hutchison, addressed the ISR teams in a pre-recorded message, praising the students’ STEM ambitions.

“Your participation in ISR contributes to our proud, innovative culture at Carderock,” Hutchison said. “Much like our workforce, you have all displayed a willingness to be adventurous in your experimental endeavors, which has led you to this event. ISR has given many students a fun, interactive platform in submarine and surface ship design. This STEM event has gained fans and participants from across the country, the world and, believe it or not, even outer space. Megan’s story is an example to follow your dreams and pursue the unexpected; you just never know what the future has in store for you.”

The ISR board recognized six winners during the awards ceremony, which was hosted online via Zoom. Awardees were presented a plaque and, in some cases, a financial reward, too. The list of winners and runner-ups, along with honorable mentions, for each award are listed below:

Subsystem Design Challenge – Human

“I look forward to seeing you all, including those teams who were unable to participate this year, at the David Taylor Model Basin for ISR17 in June 2023.”

Factors Engineering Design Process

First Place: Human Powered Submarine Team, University of Washington

Runner-up: SUBC, University of British Columbia

Subsystem Design Challenge – Drivetrain Design

First Place: SUBC, University of British Columbia

Runner-up: Human Powered Submarine Team, University of Washington

Honorable Mention: UVIC Submarine Racing Club, University of Victoria

Subsystem Design Challenge – Thrust Production Device Design

First Place: Virginia Tech

Runner-up: Texas A&M University

Honorable Mention: Godiva, University of Warwick

Subsystem Design Challenge – Maneuvering and Control Design

First Place: Human Powered Submarine Team, University of Washington

Runner-up: Virginia Tech

Honorable Mention: Godiva, University of Warwick

The Future Submarine Technical and Design Challenge

First Place: Human Powered Submarine Team, University of Washington

Runner-up: SUBC University of British Columbia

Operational Problem Solving Challenge

First Place: Human Powered Submarine Team, University of Washington

Runner-up: Virginia Tech

Honorable Mention: Southampton University Human Powered Submarine (SUHPS), University of Southampton

In addition, Hannah Douglas, a team member of the UMPTYsquatch team, was awarded the 2021 FURE scholarship. Douglas recently graduated from Sussex County Technical High School in Georgetown, Delaware, and will soon attend Wilkes University in Wilkes Barr, Pennsylvania, majoring in mechanical engineering.

While vISR 16 successfully managed to keep students engaged in human-powered submarine design, Behrle and all personnel involved in the biennial competition cannot wait to get back in the water in 2023.

“I look forward to seeing you all, including those teams who were unable to participate this year, at the David Taylor Model Basin for ISR17 in June 2023,” Behrle said. “If past races are any indication, we expect to see around 25 teams and over 500 student participants.”

WAVES

The image features a dark blue background. The word "WAVES" is written in a large, white, sans-serif font. The letter "V" is stylized, with a light blue shadow or outline that extends upwards and to the right. Below the text, there are several geometric shapes: a large white trapezoid on the right, a horizontal light blue bar on the left, and a light blue triangle on the bottom right. A small white square is also visible near the intersection of the horizontal bar and the triangle.