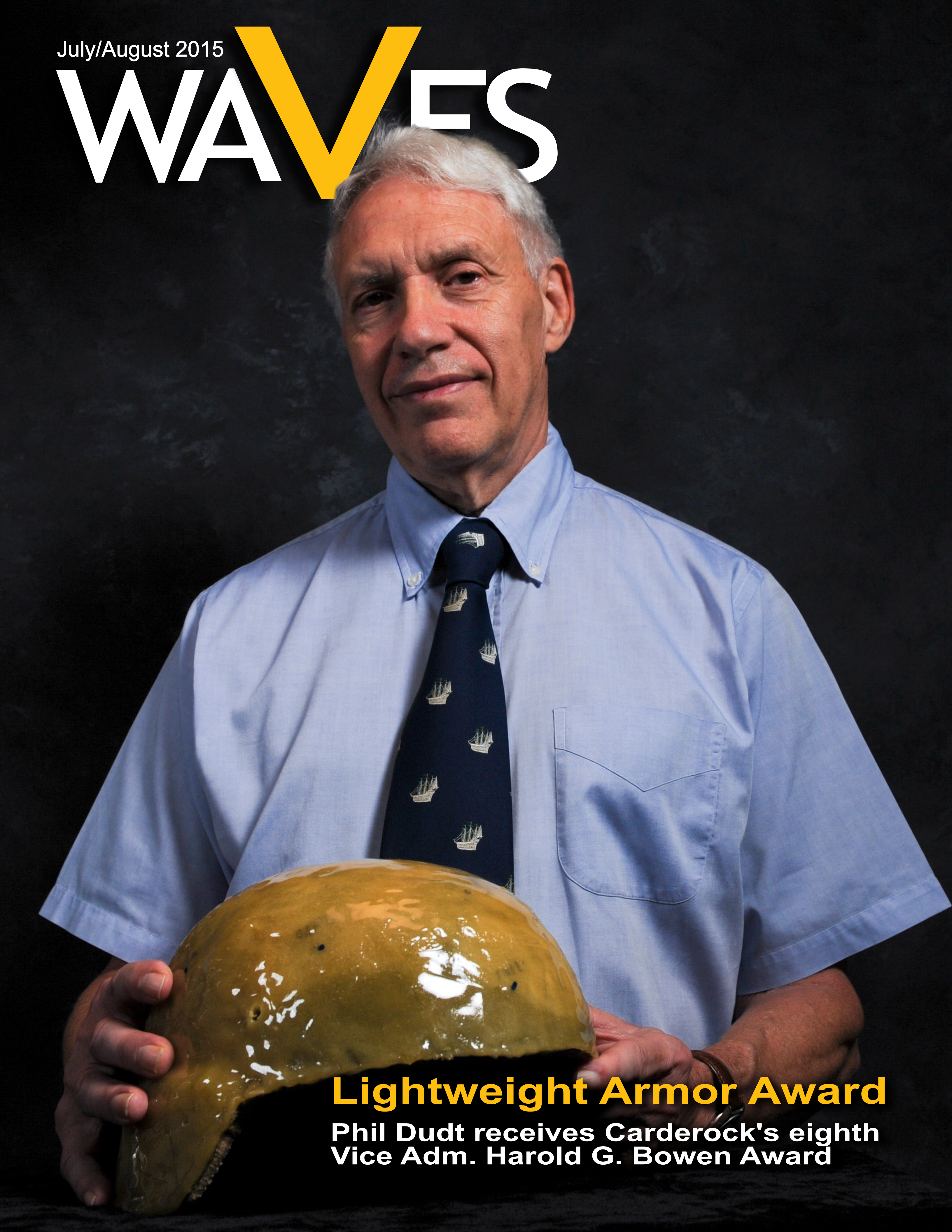
July/August 2015

WAVES



Lightweight Armor Award

Phil Dudt receives Carderock's eighth Vice Adm. Harold G. Bowen Award

July/August 2015

WAVES

INSIDE PAGE 14

Submarines and their team members wait in the staging area during the 13th International Human-Powered Submarine Races being held in the David Taylor Model Basin at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 24, 2015. (U.S. Navy photo by Devin Pisner/Released)

TEAM

Joseph Battista
Katie Ellis-Warfield
Rebecca Grapsy
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Jay Pinsky
Margaret Kenyon
Nicholas Malay
Roxie Merritt
Margaret Zavarelli

COVER

Philip Dudt, a researcher at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., is the co-recipient of the 2014 Vice Adm. Harold G. Bowen Award for Patented Inventions for his role in the patent "Armor Including a Strain Rate Hardening Elastomer." The patent, which Dudt shares with co-inventor Dr. Roshdy Barsoum, a researcher at the Office of Naval Research, is for the use of an explosive resistant coating as a lightweight alternative to armor for ships and ground vehicles. Research continues for ways to use the explosive resistant coating with the latest work involving applications of the elastomer to helmets as a means to further mitigate explosive and ballistic impact damage to personnel. (U.S. Navy photo by Jay Pinsky/Released)

Dr. Joseph T. (Tim) Arcano Jr.
NSWC Carderock Division Technical Director

Millennials: Carderock's next generation

You can see in the pages of this magazine why Carderock is renowned across the Navy and around the world for our expertise in ship and submarine science, technology, research, development, testing and evaluation and for having the very best employees who are the authorities in their subject areas. Many of our long-time employees came to Carderock to pursue their dream job and have stayed here, becoming experts in their fields and ensuring cutting-edge technology is advancing to the warfighter. I don't know of anywhere else in the enterprise where it is so common to see 20, 30 and 40 years-of-service awards being given to those who had completed all their time as a federal employee at one location. I cannot thank the Carderock team enough for their dedication to the mission.

However, while we have this admirable stability in our workforce, we must always be looking forward to the next generations. I find it astonishing to learn that a 2014 survey of millennials published by the Office of Personnel Management showed that only one-third believe that their government agency rewards creativity and innovation. How do we show potential future employees that at Carderock they will be encouraged as they join us to innovate, to hone and develop their technical skills and interests? There's not one answer.

The efforts to attract the next generations to government have to start early, especially when recruiting highly trained scientists to work in Carderock's fields of expertise. This is why we invest time and resources in science, technology, engineering and math (STEM) programs and educational partnerships with area schools. By reaching out to bright young students when they are still early in their formal education, and piquing their interest through programs like SeaPerch and SeaGlide, we have the chance to impact the course of their education and their future passions toward STEM. Building a small robot during a STEM session can turn into an advanced science or math course in high school, down the road into an engineering major and on to a master's degree or even Ph.D. in physics. This is truly the first step in making sure we are building today's workforce to meet future fleet requirements.

Our summer internship programs are a way for us to bridge the gap between our STEM education efforts and the workforce of tomorrow. Our youngest interns are high school students, with our internship programs also attracting undergraduate and graduate students. This is their opportunity to come to Carderock and do meaningful work on challenging, real projects.

Even with the best workforce in the world here, though, we can't become complacent. We have to continue to develop our less experienced shipmates, and keep them – by motivating them with challenging and meaningful assignments. This is why I believe so strongly in a mentoring program that provides the opportunity to get hands-on guidance to shape and move careers, while maintaining and expanding Carderock's institutional knowledge across generations. We encourage our employees to continue their education and offer sponsorship for advanced degrees. We bring speakers from outside Carderock and industry to ensure our workforce is always inspired and motivated by the "best and brightest" innovators both inside and outside our gates. The journeyman leadership programs offered at Carderock and NAVSEA exist to transition our rising early-career employees into leaders. We know that many of our employees have their choice of opportunities, and we continue to strive to enrich their career experience so we can retain them.

Some common attributes of millennials include: they are mission driven, they crave mentors, they seek leadership opportunities, are ambitious, they strive to invest in people and to be connected. These sound like the exact attributes we are looking for in our workforce. By mentoring and developing our junior employees, we can inspire them and ensure that they become the next generation world-class workforce that Carderock Division is known for today. This isn't an effort for leadership alone, however. All employees need to be invested in challenging and helping their colleagues to ensure we are the collective best we can be.

Millennials have grown up around technology and they are comfortable learning how to learn, which is a critical skill when it comes to learning a new tool or platform. A constant thirst for the next great thing, a restlessness for advancement and not complacency, makes for a great engineer. And when it comes to changing the world – I cannot think of a better or more meaningful way to do that than to get the privilege of serving our great Nation by supporting the mission and warfighter.

http://www.fedview.opm.gov/2014FILES/FEVS_MillennialsReport.pdf

NSWCCD scientist receives Bowen Award

By Jay Pinsky, NSWCCD Public Affairs

Dante Dobbins, a 2015 summer volunteer at Naval Surface Warfare Center, Carderock Division (NSWCCD) in West Bethesda, Md., helps Philip Dudt, a researcher at NSWCCD, test different applications of an explosive resistant coating on helmets, Aug. 8, 2015. According to Office of Naval Research (ONR) scientist Dr. Roshdy Baroum, early research sponsored by ONR, identified that a coating of explosive resistant coating polymers could mitigate blast exposure to the brain. NSWCCD is nearing final blast testing of a prototype. The coating is also being explored for use in football helmets and have a wide application in this arena. (U.S. Navy photo by Devin Pisner/Released)

Chief of Naval Research Rear Adm. Mathias W. Winter presented the 2014 Vice Adm. Harold G. Bowen Award for Patented Inventions to two U.S. Navy researchers in a ceremony at the Office of Naval Research (ONR) Wednesday, Aug. 26.

Philip Dudt, a scientist at Naval Surface Warfare Center Carderock Division (NSWCCD) in West Bethesda, Maryland, and Dr. Roshdy Barsoum, an ONR scientist, received the award, which recognizes the patented inventions of present or past Navy employees, civilian and military, that are of greatest benefit to the Navy, for their contributions as inventors to the patent "Armor Including a Strain Rate Hardening Elastomer," a lightweight alternative to armor for ships and ground vehicles. Both men are officially named as inventors on the final patent, U.S. 7,300,893 B2, granted Nov. 27, 2007, while the United States of America, as represented by the Secretary of the Navy, is the final patent holder. The award marks the eighth time NSWCCD has earned the Bowen award.

According to the Office of Naval Research, the men were recognized for their contributions by leading the effort to expeditiously identify, test and exploit an explosive resistant coating that provided a lightweight alternative to armor for ships and vehicles. According to ONR, the increased platform survivability and personnel protection associated with this class of materials provided the operational commander with the potential to reduce personnel casualties and expanded the operational envelope available during combat and peacekeeping operations.

"Without Phil and Roshdy's vision in elastomeric armor, we would not have these solutions available to our military," said Dr. Joseph Teter, NSWCCD's director of technology transfer.

The idea for the patent came during the review of underwater explosion experimental test results and ballistic test results of the explosion resistant coating created at NSWCCD to mitigate future damages similar to those suffered during the Oct. 12, 2000, USS Cole (DDG 67) disaster. "The underwater shock performance of explosion resistant coating was found to be highly capable in suppressing damage to close-in underwater threats," said Barsoum. Dudt thought if the coating from these tests could work underwater it could work well in other applications. "I'm always willing to try things, you never know where a good idea will come from," he said.

Dudt's creativity is no surprise to Alyssa Littlestone, deputy director of technology transfer at NSWCCD, who was mentored by Dudt earlier in her career. "I learned a great deal working with Phil," she said. "Not only technically, but also in terms of creativity and approach. As a mentor, Phil was supportive of out-of-the-box thinking and accepting of failure, a combination which fosters innovation. I believe his combination of technical knowledge and forward-thinking creativity is what has enabled Phil to become a successful and prolific inventor."

Dudt shared his idea of applying the elastomer polyurea on metallic surfaces for bulk explosive and ballistic protection with Barsoum, his co-inventor on the patent, who developed the concept to sandwich front and back applications of the elastomer to the armor for blast and ballistic protection. "The amazing property of the explosive resistant coating material is, as the threat increases in severity, the efficiency of the material to resist assault increases," said Barsoum. Dudt and Barsoum continued to explore the idea, sponsored by ONR, taking the elastomer to the U. S. Army's Aberdeen Proving Grounds for ballistic testing which showed promise. According to Barsoum, based on these successful, initial tests, a spray up armor was rapidly deployed for the Iraq theater for U.S. Marine Corps vehicles.

"As a mentor, Phil was supportive of out-of-the-box thinking and accepting of failure, a combination which fosters innovation."

Research with the elastomer continues today with global participation inspired by the patent. "This patent was one of the first stepping stones for other people to take this technology further," said Dudt.

According to Teter, the use of the elastomer led to significant cost savings estimated at $7.8 million in the first year of up-armor production. Additionally, Teter noted the elastomeric up-armor was lighter than the equivalent amount of steel add-on armor, saving 2,000 pounds per vehicle, which put less stress on the vehicle power plant and drivetrain increasing vehicle service life.

"While this invention helped the military to save cost and increase our military capability in terms of vehicle life, and operational envelopes, this innovation most critically helped to increase the protection of America's warfighters in theater ultimately mitigating and preventing their injuries," said Teter.

Rear Adm. Mathias W. Winter, chief of naval research, presents the Vice Adm. Harold G. Bowen Award for Patented Inventions to Dr. Roshdy Barsoum, left, from the Office of Naval Research (ONR), and Phillip Dudt, from the Naval Surface Warfare Center Carderock Division, during a ceremony held at ONR in Arlington, Va., Aug. 26, 2015. (U.S. Navy photo by John F. Williams/Released)

NAVSSES engineers help Norfolk Naval Shipyard make dry dockings more efficient

By Joseph Battista, NAVSSES Public Affairs

Engineers at Naval Ship Systems Engineering Station (NAVSSES) are creating a virtual 3-D model of Norfolk Naval Shipyard's (NNSY) dry dock three, currently housing USS La Jolla (SSN 701), from laser scans taken June 11-18 to create an advance-planning 3-D layout of the site for determining optimum placement of support services during future dry dockings.

NAVSSES engineers Scott Storms, Patrick Violante, and Kyle Verrinder did 340 scans using two scanners to capture the dry dock, docked submarine and pier side structures. The 3-D layout they create from the scans will help NNSY determine the best ship docking block positions, pier side temporary support services locations, temporary dry dock trailer placements, transport dry dock crane assemblies, toolbox locations and external ship scaffolding locations.

USS La Jolla is being converted into a moored training ship (MTS). The scan of the dry dock with the La Jolla will help them plan for their next project – converting USS San Francisco (SSN 711) to a training vessel.

"The scans taken by NAVSSES for this proof-of-concept project will benefit NNSY by capturing the various conditions of SSN 701 and the associated dry dock arrangements as the ship is converted into a moored training ship (MTS)," said B. Maria Williams, nuclear engineer and lead for NNSY 3-D Printing and Scanning Subcommittee. "This data will be used for planning of the next MTS conversion of SSN 711 beginning soon."

According to Storms, mechanical engineer with Advanced Machinery Systems Integration Branch, this project developed during a meeting to discuss how Naval Sea Systems Command's (NAVSEA) Warfare Centers can use their innovation resources to support Navy shipyards.

"As part of the Warfare Center Innovation Support to Naval Shipyards effort, this waterfront 3-D scanning of dry dock and services project was chosen as one with great benefit to all Navy shipyards," Williams said.

Violante, electrical engineer with Advanced Machinery Systems Integration Branch, said NNSY is in the process of obtaining the technology. They are shadowing his team during the scanning to learn about its capabilities.

"During this project, we are showing them what they can do with the equipment," said Verrinder, mechanical engineer with Power Transmissions branch. "Eventually they can

Engineers at Naval Ship Systems Engineering Station create a virtual 3-D model of Norfolk Naval Shipyard's dry dock four June 11-18 to create an advance-planning 3-D layout of the site for determining optimum placement of support services during future dry dockings. (Screenshot provided by Scott Storms/Released) start doing this on their own with the other dry docks at Norfolk."

Storms said every ship dry docking is different – requiring different tools, erecting scaffolding in a different spot and placement of trailers varies. Having a 3-D model allows planners to create the layout before the ship is dry docked and support elements delivered.

According to Williams, NNSY reduces the time spent developing planning drawings for the next dry dock availability after scanning a facility or piece of equipment because the existing data remains the same.

"Modifying 3-D model drawings is less time intensive than doing the same modification to a 2-D drawing where lines and objects aren't dimensionally associated to each other and must be manually modified," Williams said.

NAVSSES' 3-D layout gives NNSY precise measurements to work with. According to Storms, having the 3-D model helps them plan the various stages of a dry docking. There is no lag time in putting up scaffolding and different services no longer fight for space.

"Because the depth line on one side of the dry dock says 6-feet, doesn't mean the other side is also exactly 6-feet," said Storms. "There can be a difference of an eighth-of-an-inch or so that can affect the placement of block positions. They can use our scans as a validation tool for all their measurements."

Violante said their biggest obstacles during the six days of scanning were heat and scheduling. Unusually hot temperatures forced the team to stop work intermittently to cool the equipment to keep it operational.

They also were scanning at an active work site. A people-free environment is ideal for scanning, Storms said. To remedy both problems, the team decided to do most scanning between the hours of 3-8 p.m. when the temperatures were lower and fewer people were working.

"Ideally we would've liked to do the scanning at night when the temperatures were much cooler and there were no workers on the submarine, but our scanning equipment works much better in sunlight," Storms said.

Storms said they plan to continue doing scans at NNSY throughout the phases of USS La Jolla's dry docking to get a full representation of the entire process. They also hope to do at least one quality scan of a dry dock at every Navy shipyard to use as a starting point for determining optimum placement of support services during future dry dockings.

Commonality training pilot program starts at Naval Ship Systems Engineering Station

By Joseph Battista, NAVSSES Public Affairs

A commonality pilot training module was reviewed by Naval Ship Systems Engineering Station (NAVSSES) senior management, approved and launched in the Total Workforce Management System (TWMS) for NAVSSES employees to support Naval Sea Systems Command's (NAVSEA) Enterprise Commonality Office's (SEA 06C) strive to reduce the number of unique systems, subsystems and components introduced into the fleet inventory through new ship acquisition programs and major modernization programs.

Bill Moss, the Commonality Team lead with NAVSSES, said the goal of the training is to improve the NAVSEA enterprise's employee awareness of the commonality roles and responsibilities and implementation process so it becomes a culture change in how the Navy does business. NAVSSES is serving as the test location for the initial training where it will be evaluated and tweaked before a full rollout to other NAVSEA activities.

"Working together with NAVSEA 06C, Commonality program office, we plan to eventually roll this out to other commands," Moss said. "We hope to expand this training effort to all public and private shipyards, as well as all the Warfare Centers and regional maintenance centers."

Previously, Moss and his team conducted individual training sessions for small groups of employees at NAVSSES and other NAVSEA activities. This took a lot of time, was not efficient and the team came to the realization that as the effort grows, it would be near impossible to do face-to-face training throughout the Warfare Centers and beyond.

"We needed to come up with something on a broader scale," said Nick Mangraviti, engineering technical specialist with Provisioning and Supply Support Branch at NAVSSES. "We determined that the most efficient way to reach everyone with this training is by making it computer based."

Moss said their goal was to create a training package that covers the critical material concerning commonality. The training concludes with a short quiz that Moss said is strictly to help the user determine their understanding of commonality and for the commonality team to determine the effectiveness of the computer-based training. There is no requirement to pass the quiz to receive credit for taking the training.

"The quiz simply helps us keep metrics on the effectiveness of the training," Moss said. "If we see that a lot of people are getting one specific question wrong, then we can take a look at it and see if we need to reword it or maybe remove it altogether."

The training module explains NAVSEA Enterprise Commonality, gives the background of commonality within NAVSEA, describes the use of deep dives in achieving commonality and teaches how to use the virtual shelf as a tool for achieving commonality.

"The goal of the training is to improve NAVSEA's employee awareness of the commonality implementation process so that it becomes a culture change in how we do business – integrate it into our daily work habits," Moss said.

Any NAVSSES employee required to take the training will be notified by TWMS or if you are interested in taking the training on your own, you can contact the Commonality Team at commonality.navsea@navy.mil to request the training separately.

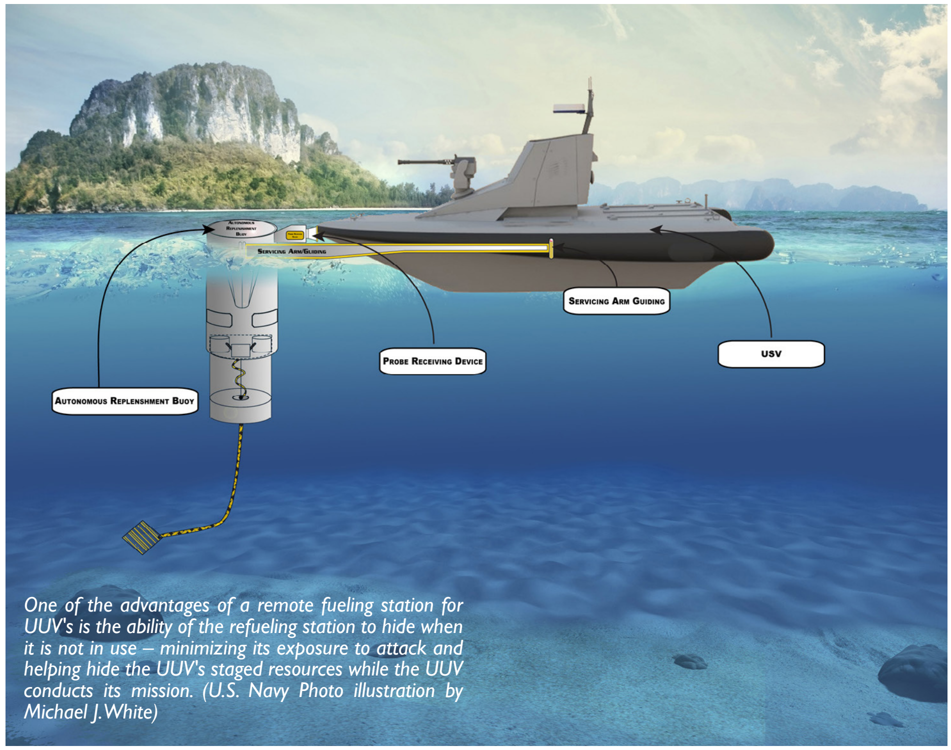
The NAVSEA Enterprise Commonality Office is a function of the recently created SEA 06 Acquisition and Commonality Directorate. SEA 06C is creating policies, processes and awareness in order to enable strategic commonality implementation in new construction, maintenance and modernization programs throughout the Navy.

Remote autonomous replenishment buoy for sea surface craft

By Jay Pinsky, NSWCCD Public Affairs

Naval Surface Warfare Center, Carderock Division is an idea factory, and some of the best ones are patented.

Such is the case for a clever concept known as the remote autonomous replenishment buoy for sea surface craft. The idea, which was officially patented as U.S. 8,943,992 B1 to the Department of the Navy by the U.S. Patent and Trademark Office Feb. 3, 2015, was developed by a team of engineers at Naval Surface Warfare Center, Carderock Division (NSWCCD), who were inspired by the concept's potential to enable unmanned surface craft to refuel themselves.



One of the advantages of a remote fueling station for UUV's is the ability of the refueling station to hide when it is not in use – minimizing its exposure to attack and helping hide the UUV's staged resources while the UUV conducts its mission. (U.S. Navy Photo illustration by Michael J. White)

"The ability to reduce the human workload through implementation of more intelligent systems on manned craft or even more importantly, through the employment of unmanned surface vessels (USVs), and to take the operator out of harm's way is just too important to not get excited about," said Scott Petersen, head of the Combatant Craft Systems Design and Integration Branch in the Naval Architecture and Engineering Department at NSWCCD. Petersen's two partners on the patent were Robert Galway of the Launch and Recovery, Boat and Ship Interoperability and Boat Machinery Branch, and Barney Harris, a contractor for CDI Corp. at NSWCCD, who served as the principal engineer. All three are listed as co-inventors on the official patent which was originally filed June 27, 2013.

What exactly is the remote autonomous replenishment buoy for sea surface craft? According to the patent language, the invention is "an autonomous replenishment buoy for servicing one or more water vessels wherein each of the one or more water vessels has a probe extending from the bow of the respective water vessel." The patent describes the autonomous replenishment buoy as having a main cylindrical body and a fuel receptacle within the main cylindrical body. The sea-based buoy has a mating system for the visiting sea vessel, and uses one or more servicing arms with energy absorbing and guiding portions to guide and absorb the energy of an incoming water vessel. It essentially corrals and guides the unmanned surface craft to the fuel section of the buoy. When not in use, the refueling device could reduce its signature by retracting its arms giving the device more portability and stealth when not in use.

According to Harris, this patent is actually the fourth patent that relates to the handling and support of unmanned surface vessels with the other three being U.S. 8,568,076, U.S 8,359,993 and U.S. 7,975,638. "These and the other patents are significant since they chronicle a portion of the development of the technological base that will, with others, ultimately enable the broad application of unmanned surface vessels" Harris said.

> "The ability to reduce the human workload through implementation of more intelligent systems on manned craft or even more importantly, through the employment of unmanned surface vessels and to take the operator out of harm's way is just too important to not get excited about."

According to Petersen, the ability to refuel remotely gives USV advocates key tactical and strategic developments for unmanned surface craft, including missions for the littoral combat ship (LCS), mine counter measure and unmanned influence sweep system (UISS) programs. Galway expanded Petersen's logic. "You would increase the energy efficiency of the total system by removing the need to refuel at a ship every several hours, so you reduce transit time," he said. "You also reduce the need to launch and recover the USV to refuel it, which is by itself an inherently risky and time consuming evolution. We lower the risk to the USV's parent ship and its crew by eliminating the need for the ship to expose itself to refuel the USV." In fact, Galway said, solving the refueling riddle serves as a watershed engineering moment for other USV advancements. "Developing the suites of technologies associated with unmanned refueling of USVs is one of the first technologies needed to extend the mission capability of USVs from a single load of fuel to being fuel load independent."

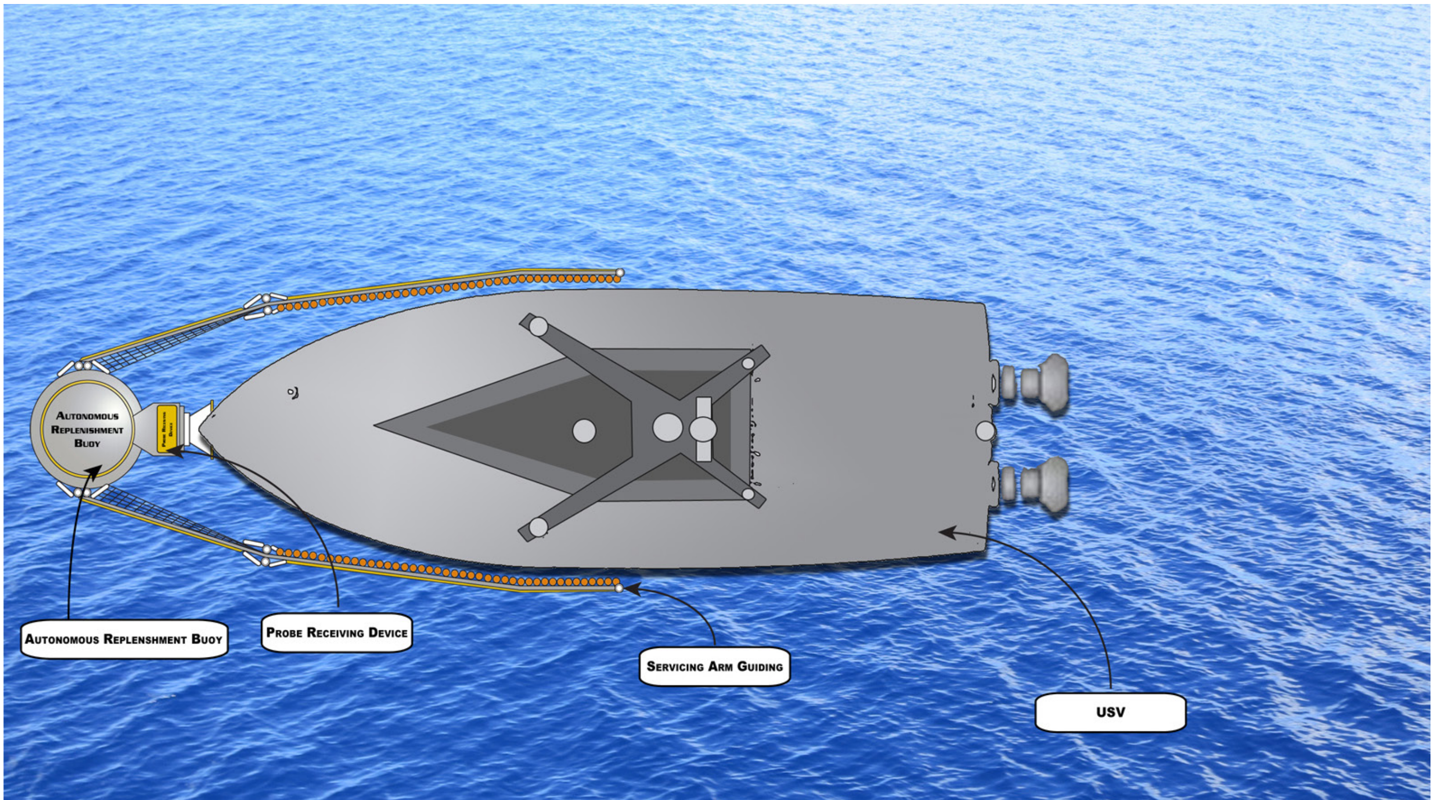
Petersen said the device has a domino effect on the mission effectiveness of not only the unmanned craft itself, but also all of its supporting equipment and personnel as well. "If we could drop fuel for the UISS, it would free up LCS and also reduce the transit time to the ship which necessarily stands off from the minefield," Petersen said. "The LCS is minimally manned, so focusing on refueling could be the total focus of the ship. Secondarily, when you think about it, a USV offers the capability to remove the man from the environment. This is not just removing him or her from danger, but also removing him or her from long dwell time on station. The ability of a USV to refuel when it runs low can increase its persistence or range while crews rotate in and out comfortably on shore (or host ship) increasing the crew's effectiveness and overall morale."

The team said throughout the development process there were several key engineering challenges and breakthroughs that inspired the engineers intellectually. "One of the most difficult areas is making the initial connection between a USV and a stationary object," Harris said. "This is an area in which very little work has been done. We derived several concepts that appear workable from an aperture and energy dissipation stand point. Subsequently we have generated still more design concepts. More work will be needed to reduce these to hardware that can be tested."

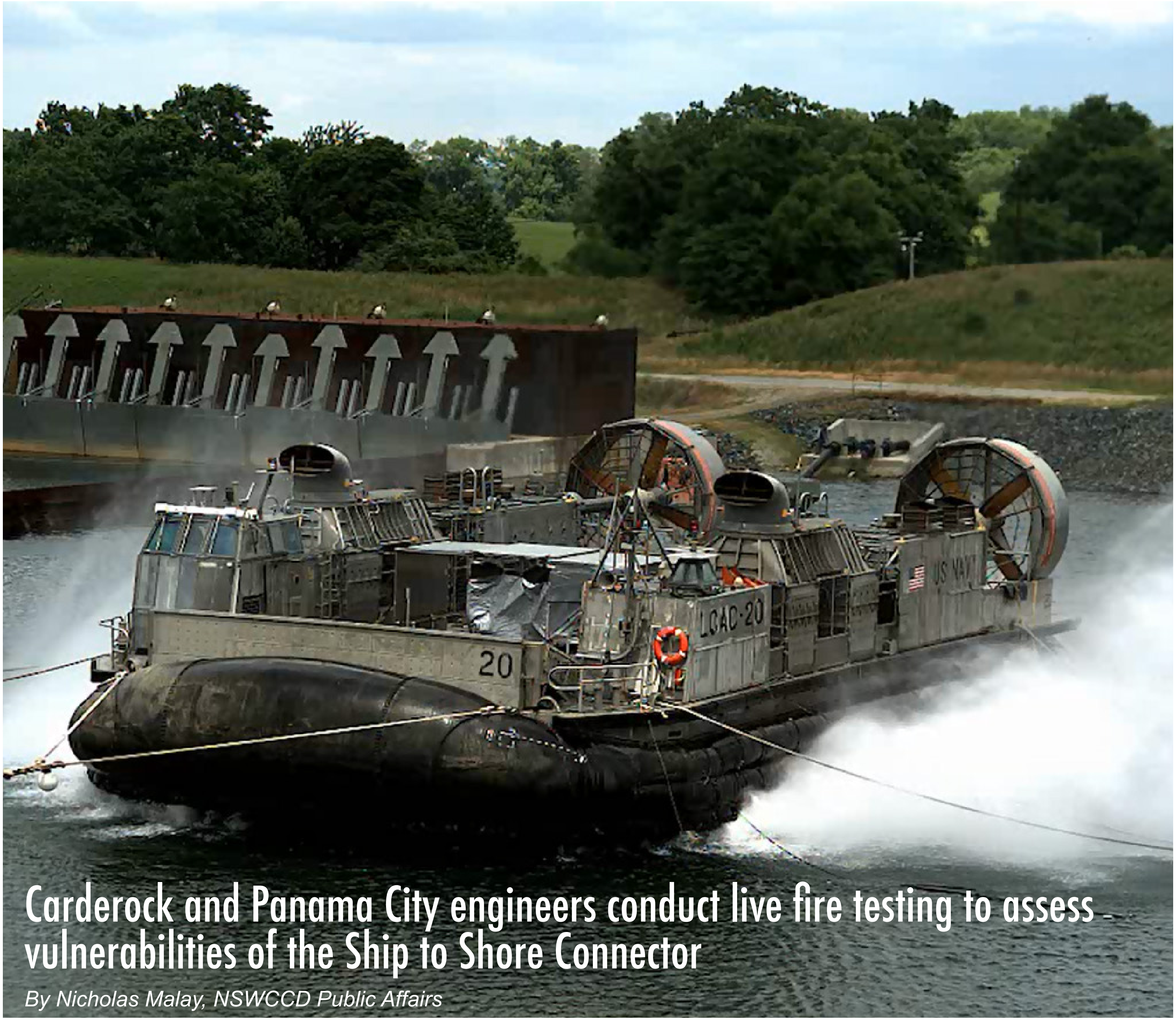
Galway agreed with Harris attributing their team's work as a pioneering effort very similar to another branch of relatively new naval history. "I think we are in the infancy of USV use in the U.S. Navy," Galway said. "A neat parallel might be naval aviation. Seventy-five years ago you may recall seeing some of the first pictures of launching and recovering aircraft with sandbags on the deck to slow aircraft. Now we have a systems command dedicated to aviation with Naval Air Systems Command. The next 50 to 100 years will include growth of USV use in a similar way. It would not surprise me at all to see a naval unmanned surface vessel systems command in the future. The nice thing here is we can use lessons learned from the aviation community to assist us and accelerate our development."

Successes aside, there are still opportunities and obstacles within the realm of the emerging unmanned surface craft world yet to be encountered, according to Petersen. "The challenge is that unmanned surface vehicles are not fielded, and the true scope of their utility to the next Navy or Navy after next is still not known."

In the end, when the reality of this aquatic self-service gas station began to materialize, the team's enthusiasm and confidence grew. "The success on this project has given me the belief that I can influence the success of the Naval USV in the future," Galway said. "It is empowering, and motivating to get me to want to do more."



The ability to refuel a USV remotely helps maintain the UUV's autonomy while on mission and minimize the danger of the parent ship's crew because they don't have to conduct refueling operations. (U.S. Navy Photo illustration by Michael J. White)



Carderock and Panama City engineers conduct live fire testing to assess vulnerabilities of the Ship to Shore Connector

By Nicholas Malay, NSWCCD Public Affairs

Landing Craft Air Cushion (LCAC) 20, used as a surrogate for the Ship to Shore Connector live fire testing, hovers in the littoral warfare environment test pond at Aberdeen Proving Ground located in Aberdeen, Md., prior to the first shot, June 16, 2015. This photo shows the remotely controlled, unmanned, fully operational, LCAC hovering in the test pond just prior to a weapon's attack. (U.S. Navy photo by Gordon Eisner and Anthony Renna/Released by U.S. Army Aberdeen Test Center)

The Live Fire Program for the Navy's Ship to Shore Connector (SSC) recently completed three system-level tests using a retired Landing Craft, Air Cushion (LCAC) as a surrogate for the SSC to assess vehicle vulnerabilities.

The SSC program, managed by the Amphibious Warfare office (PMS 377) in PEO Ships, will build 72 production craft that will serve as the evolutionary replacement for the existing fleet of LCAC vehicles. As the Navy's experts in the survivability of Navy platforms, Naval Surface Warfare Center Carderock Division (NSWCCD) led the testing, in partnership with Naval Surface Warfare Center, Panama City Division (NSWCPCD), which specializes in littoral and mine warfare.

"As required of all manned weapon systems, which includes naval ships and craft, the SSC must undergo realistic survivability testing, prior to its full rate production, to determine the vulnerability of the craft and its crew to threats likely to be encountered in combat," said Gerald Lawler, NSWCCD senior vulnerability analyst for combatants. "When a weapon system is considered to be unreasonably expensive to destructively test, such as naval vessels, the live fire legislation allows for the testing of surrogates in place of the actual system."

Given that the SSC is being designed to replace the LCAC and is similar in its overall dimensions, skirt system and propulsion machinery to the LCAC, the overall damage to the LCAC for the threats tested would be expected to be similar to the damage inflicted upon an actual SSC.

Testing timeline:

In July 2012, "the Navy announced the retirement of several LCACs in the fiscal year 2014 to fiscal year 2015 time frame," Lawler said. "The potential availability of these craft provided the program sponsor, PMS377, the opportunity to perform a full-up system level test on an operational SSC surrogate as part of its overall Live Fire testing program."

Discussions with Assault Craft Unit FOUR (ACU-4) began in March 2013 as to the potential craft candidates and the transit of the craft, approximately 165 miles, to a test range at Aberdeen Proving Ground (APG) in Aberdeen, Maryland.

In June 2014, LCAC 20 was selected by ACU-4 as the test craft.

On April 27, the LCAC 20 and its escort craft, LCAC 37, arrived at the UNDEX Test Facility off of the Bush River at APG.

Testing background:

During the two-year time frame prior to the arrival of the LCAC at APG, Lawler and Ben Ridenour, NSWCCD Vulnerability Assessment branch engineer, developed the test plan, that when implemented, would have to answer SSC critical live fire issues to satisfy the Live Fire Office within the Operational Test and Evaluation Directorate at the Pentagon, while safely conducting a test involving live ordnance and an unmanned operational LCAC. "Bringing together LCAC expertise from NSWCPCD, active Navy ACU-4 support and weapons effect testing expertise from the Army's Aberdeen Test Center with NSWCCDs Vulnerability Assessment Branch expertise in live fire program management and test development was the key factor in achieving these goals," Lawler said.

"Aside from obtaining a fully mission capable craft from the Navy for destructive testing, one of the greatest challenges of this test was that the craft had to be operational, on cushion and under control without an on-board crew due to the presence of live ordnance," Lawler said. "To achieve this condition, a wireless, remote control system was developed by NSWCPCD."

NSWCPCD engineers successfully installed and operated this remote-control system throughout testing enabling the start of the craft's main engines and the inflation of the skirt while the craft was unmanned, but tethered, in the test pond.

NSWCPCD's extensive knowledge and experience with the surrogate system, as LCAC ISEA, provided unique insight to the effects of the live fire testing on the craft during post-test battle damage assessments.

Three tests were conducted using actual threat weapons against the operational craft:

Live fire test 1:

The first test, conducted June 16, took place in the Littoral Warfare Environment (LWE) test pond at APG. This test examined the vulnerability of the craft and crew to surf zone mines. The crew was represented with fully outfitted anthropometric test devices (ATD). ATDs are essentially crash dummies that are capable of measuring the forces and accelerations the crew would be subjected to from the weapon effects. Crew injuries were calculated using data from the ATDs.

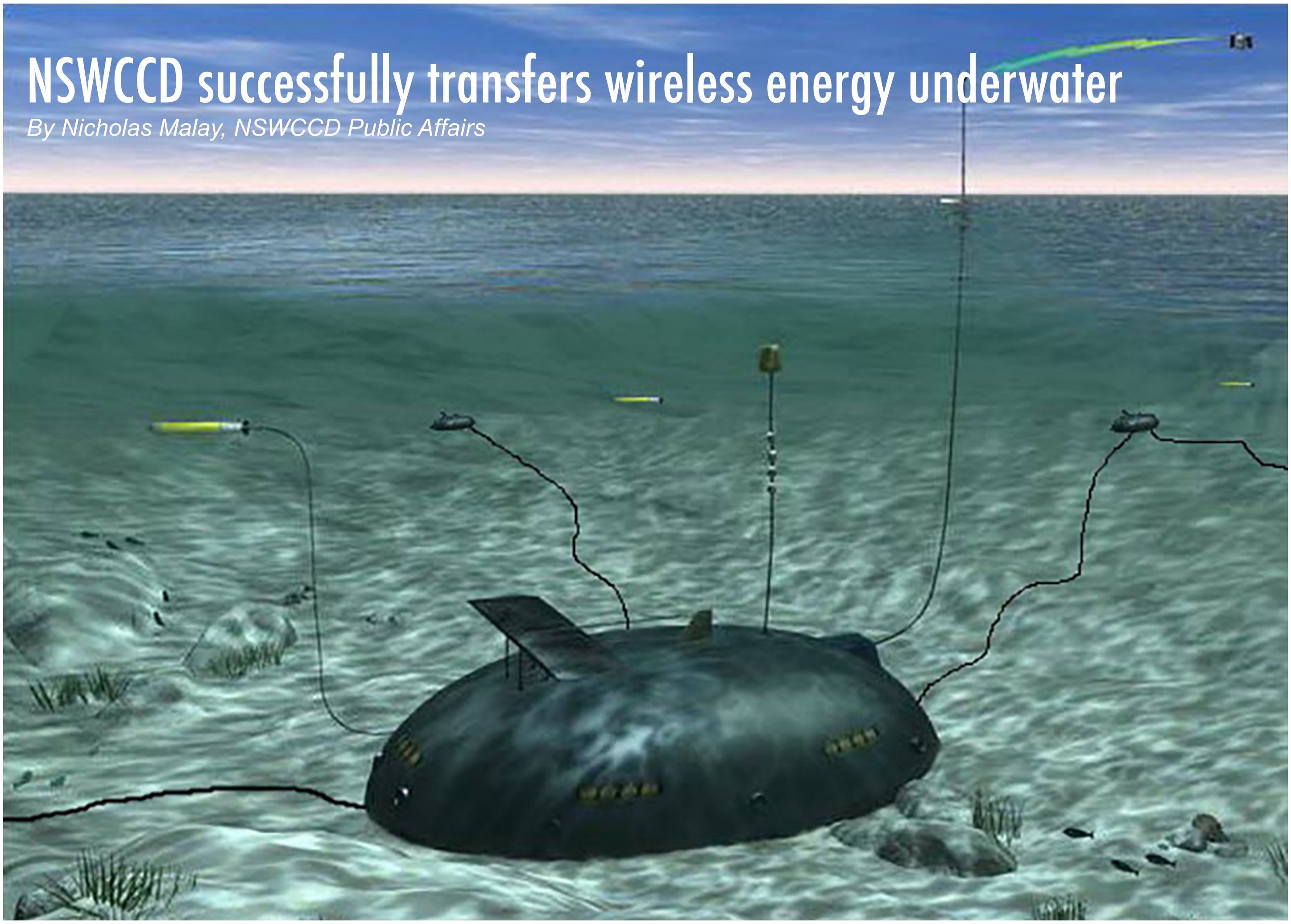
Live fire tests 2-3:

Shots two and three were conducted July 1 and July 28 on land at the LWE and examined craft and crew vulnerability to an indirect fire threat and a land mine. Crew casualty assessments for each shot were determined by the Army Research Lab (ARL) using the data collected from the tests and crew casualty assessments tools developed by ARL.

NSWCCD assessed the weapon effects damage to the craft and the degradation of the craft's systems from successive threat impacts.

"Despite the enormity of the task of conducting several live fire tests against an operational naval vessel, all tests were successfully conducted and fully achieved their live fire test objectives," Lawler said. "This achievement was due in no small part to the cooperation, expertise and professionalism of all the participating agencies under the direction of NSWCCD and the confidence of PMS377 in having the NSWCCD Vulnerability Assessment branch manage and implement the SSC Live Fire Program."

Benjamin Ridenour, Naval Surface Warfare Center, Carderock Division engineer, inside the hull of the Landing Craft Air Cushion 20 craft, used as a surrogate for the Ship to Shore Connector during live fire testing at Aberdeen Proving Ground located in Aberdeen, Md., documents the pre-test condition of the craft prior to the third shot, July 22, 2015. Ridenour is documenting the condition of the hull and identifying all of the cables and pipes running through the area of the hull that is expected to be damaged during the test event. This information is required in order to assess post-test system degradation. (U.S. Navy photo by David Rea /Released by U.S. Army Aberdeen Test Center)



NSWCCD successfully transfers wireless energy underwater

By Nicholas Malay, NSWCCD Public Affairs

A collaborative project that includes Naval Surface Warfare Center, Carderock Division and Naval Undersea Warfare Center, Division Newport involves prototyping and evaluating technologies for the vision of the Navy's Constellation, such as an undersea outpost that would serve as a filling and charging station for UUVs. (U.S. Navy graphic courtesy of NUWC DIVNPT/Released)

To make underwater unmanned vehicles (UUVs) more valuable to the Navy, Naval Surface Warfare Center, Carderock Division (NSWCCD) is researching and developing ways to recharge UUVs through undersea wireless technology, multiplying their effectiveness.

Carderock is supporting Naval Undersea Warfare Center, Division Newport's (NUWC DIVNPT) first-ever Naval Technology Exercise (ANTX), a weeklong showcase of Undersea Constellation technology from NUWC DIVNPT, and Space and Naval Warfare Systems Command (SPAWAR) Systems Center Pacific (SSC PAC), Aug. 10-14 at the Stillwater Basin Test Facility located in Newport, Rhode Island.

Prior to the ANTX, NSWCCD successfully executed an underwater wireless energy transfer demonstration in West Bethesda, Maryland, June 29-July 3 in a 6,000 gallon tank. Today, undersea vehicles enable the U.S. Navy to counter mine warfare threats, optimize remote sensing platforms, and map the ocean floor.

"We want to recharge a battery underwater through wireless technology, and we want to know the batteries charge to the highest fidelity," said Mayer Nelson, NSWCCD technical project manager.

This work was sponsored by Carderock Division under the Naval Innovative Science and Engineering program, managed by NSWCCD Director of Research, Dr. Jack Price.

The genesis of these concepts of wireless underwater energy transfer was conceived in the NSWCCD Disruptive Technologies Lab (DTL) headed by Garry Shields. The team consisted of support from NSWC Crane, NSWC Panama City, Naval Undersea Warfare Center, the Office of Naval Research (ONR) and SSC PAC. ONR funded the project through their Innovative Naval Prototype (INP) program as a collaboration of Navy labs with industrial partners.

"Underwater data and energy transfer are expected to multiply the effectiveness of Navy-operated UUVs and other unmanned platforms by providing a vehicle-agnostic method for autonomous underwater energy charging," said Alex Askari, NSWCCD technical lead. This technology can be used on different types of vehicles.

The demonstration was a collaborative effort as Carderock hosted teams from NUWC

DIVNPT and SSC PAC. “The NUWC team was on-hand to simulate the full capabilities of the NUWC-developed Mid-sized Autonomous Research Vehicle (MARV) UUV, as well as to provide assistance with testing,” said Joseph Curran, NSWCCD integration lead. The MARV is used for testing new technologies for UUV programs.

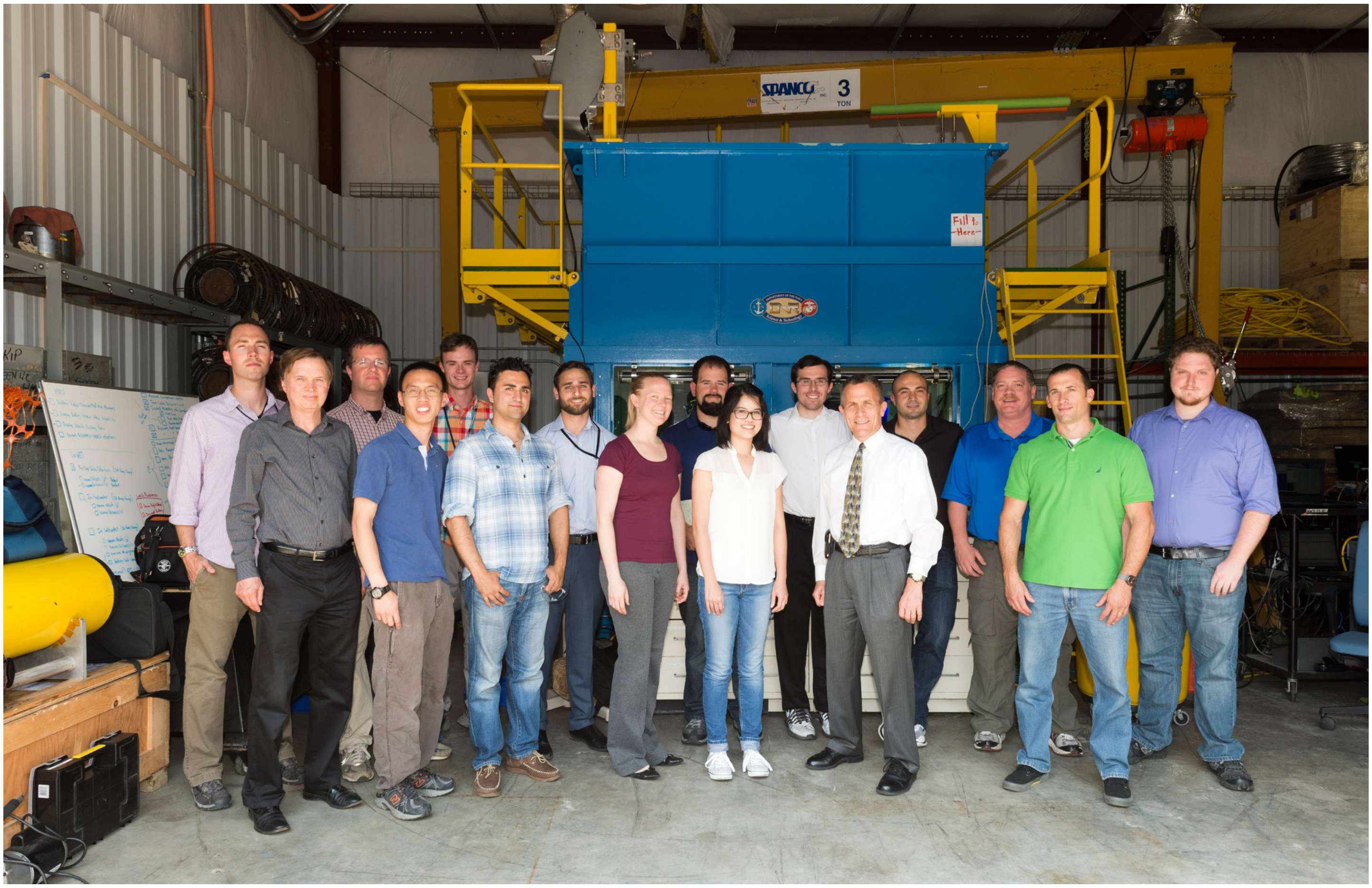
Carderock Division’s developed technology enables power transmission between underwater systems, such as UUVs. During the main demonstration on July 3, “the team was successful in transferring power wirelessly from an underwater docking station to a MARV UUV section, and ultimately to the UUV's battery, which was charged at 2 kilowatts while submerged,” Nelson said.

“Three teams from SSC PAC were on hand to demonstrate underwater optical communications, acoustic communications, topside data accumulation and display Multi-Robot Operation Control Unit (MOCU) software,” said Kevin Lin, NSWCCD electrical engineer.

A battery State of Charge (SOC) program developed by Dr. Michael Knauff, an electrical engineer at Naval Ship Systems Engineering Station (NAVSSES) in Philadelphia, was integrated by Crystal Lutkenhouse, a NSWCCD mechanical engineer. “We tested a Carderock-developed algorithm and pulled in data from the actual battery; then ran voltage, current and temperature data through the data acquisition system,” Knauff said. The SOC algorithm was codeveloped with Dr. Steve Miller, a NAVSSES mechanical engineer and Tristan Wolfe, a NAVSSES mechanical and aerospace engineer.

During underwater energy transfer, this program was run using data that had been transferred wirelessly underwater using SSC PAC’s optical communications system and allowed an enhanced estimation of the charge on the battery through the SOC program.

“NUWC DIVNPT and its partners have a tremendous amount of technology to showcase,” said Michael Ansay, NUWC DIVNPT Autonomous Underwater Vehicles Branch head. “Instead of presenting it all at disparate times, much of it could be consolidated into a one-week exercise. Present and future admirals would have the benefit of seeing future Navy technologies packaged into an organized annual event that they can plan around.”



NSWCCD successfully executed an underwater wireless energy transfer (UnWET) demonstration, June 29-July 3, in West Bethesda, Md., in a 6,000 gallon tank in the UnWET laboratory, July 1, 2015. The (UnWET) demonstration team included from left: Dr. Burton Neuner, SSC-PAC optical communications lead; Dr. Robert Stark, NSWCCD UnWET physicist; Joseph Curran, NSWCCD- UnWET integration lead; Kevin Lin, NSWCCD UnWET electrical engineer; William Gottwald IV, NSWCCD NREIP intern; Alex Askari, NSWCCD UnWET technical lead; Mayer Nelson, NSWCCD demonstrator program manager; Crystal Lutkenhouse, NSWCCD mechanical engineer; Nick Frade, NUWC DIVNPT ANTX test director; Kim Nguyen, SSC PAC MOCU integration lead; Dr. Michael Pfetsch, SSC PAC acoustic communications support; Dr. Tim Arcano, NSWCCD technical director; Dusan Radosevic, SSC PAC acoustic communications lead; Stuart Beazley, NUWC DIVNPT MARV software lead; Laureano Costa, NUWC DIVNPT docking lead; and James Wagner, SSC PAC acoustic communications support). (U.S. Navy by Devin Pisner/Released)

Student submarine teams pedal steadfast

By Nicholas Malay, NSWCCD Public Affairs

Texas A&M University's human-powered submarine racing team readies their boat, The 12th Mantaray, prior to their third official run, June 23, 2015. The all-student team set a new Texas A&M University record with a top speed of 5.797 knots during the 13th International Human-Powered Submarine Race held in the David Taylor Model Basin at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md. (U.S. Navy photo by Jay Pinsky/Released)

The 13th biennial International Human-Powered Submarine Races (ISR) sponsored by the non-profit Foundation for Underwater Research and Education (FURE) and supported by the Office of Naval Research (ONR) and Program Executive Office (PEO) Submarines was held at Naval Surface Warfare Center, Carderock Division (NSWCCD) June 22-26.

The challenge was for middle school, high school and college students to design, build and race a one- or two-person, human-powered submersible to propel in an underwater course stretching 100 meters in the historic David Taylor Model Basin's (DTMB) 1,886 foot-long and 22 feet-deep water basin.

"We were honored to be a part of such an inspiring event that brought science, math and naval architecture skills learned in the classroom and lab to real-life application," said NSWCCD Commanding Officer Capt. Rich Blank. "Participants from around the globe were hard at work tweaking their new submarine designs and we thoroughly enjoyed seeing their creative efforts, innovative approaches and teamwork in action at this year's ISR."

The state-of-the-art basin equipment allows Department of Defense engineers and scientists to determine the seakeeping qualities and propulsion characteristics of small scale models in either uniform or irregular waves. The shallow water and deep water basin's water level can be varied to simulate rivers, canals and restricted channels. 8,870,000 gallons of D.C. tap water fill the basin for small scale model trials of submarines and surface ships and events such as the ISR.

ISR is a unique international engineering design competition that inspires students of the various engineering disciplines to pursue careers in science, technology, engineering and math (STEM).

Over the 13 years of ISR 323 teams have built and raced 263 designs, engaging more than 2,800 contestants.

"There is a great spectrum of STEM activities from Legos, First Robot, SeaPerch through Navy commands, academia, industry and volunteer organizations," said Kurt Yankaskas, executive director of the ISR. "In designing and building a human-powered submarine, the International Submarine Races is a manned system in the water, giving participants the engineering skills needed by the U.S. Navy and maritime industries."

For the purpose of this event, a submarine is

Submarines and their team members wait in the staging area during the 13th International Human-Powered Submarine Races being held in the David Taylor Model Basin at the Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 24, 2015. (U.S. Navy photo by Mass Communication Specialist 1st Class Clifford L. H. Davis/Released)

defined as a free flooding vehicle that operates entirely beneath the surface of the water carrying one or two occupants. A propeller system is defined as a water-coupled device with radiating blades that create thrust when spinning. A non-propeller system is defined as any other water-coupled device that creates a thrust when operated.

In the case of a two-crew submarine, only one of the crew shall provide propulsion, while the other provides navigational, safety and steering functions. Submarines participating in the ISR fall into one of the following categories: one-person submarine – propeller driven; one-person submarine – non-propeller driven; two-person submarine – propeller driven; and two-person submarine – non-propeller driven.

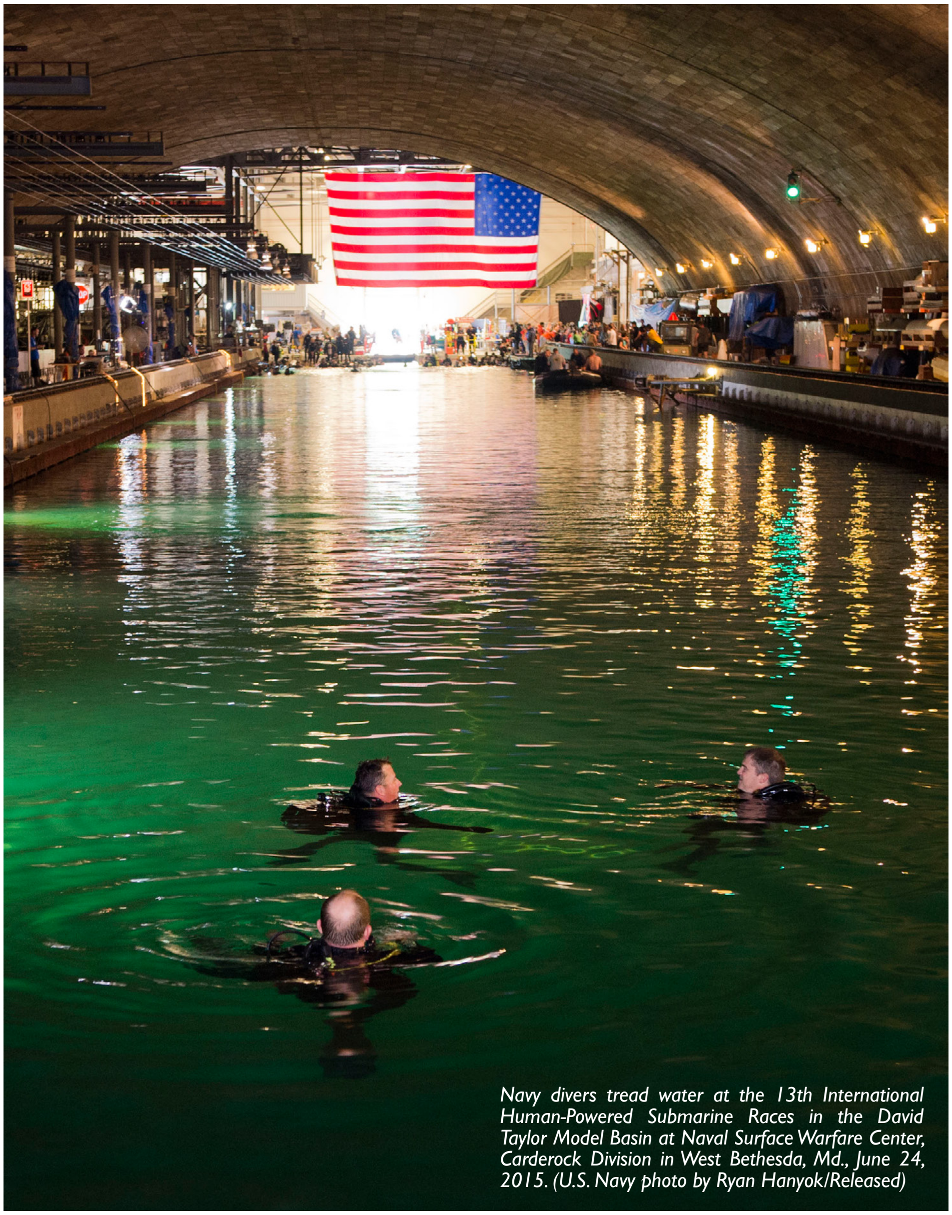
"There is a continuing need to improve the efficiency of hydrodynamics, propulsion and life support systems for small, subsea vehicles," said President of the FURE retired Navy Capt. Charlie Behrle. "Profound lessons may be learned through the process of designing, building and operating an optimized design. The rules of this competition restrict vehicle's power to human power, thus focusing attention on maximizing the submersible's design and life support system."

Human power has been the chosen propulsion plant because of its safety, fairness and the unique engineering challenges it provides, ever since the first ISR was held in Florida in 1989. The ISR has been hosted at NSWCCD since 1995. Since 1989, the ISR competition has grown to include participation from high schools, home-schools, colleges and universities from all over the world.

Teams design and build a one- or two-person "wet" submarine, relying upon the principles of hydrodynamic design, buoyancy, propulsion, guidance systems, underwater life support and systems engineering. The teams race the submarines using scuba equipment in the 3,200 foot-long model basin facility, which also houses the joint shallow water and deep water basin and high-speed basin. The facility is enclosed by an arched reinforced concrete roof. Wavemakers in the joint shallow water and deep water basin produce head and following waves.

"At ISR 13, there is an incredible level of teamwork in the diving communities – U.S. Navy, ISR volunteers and contest divers to have a great event," Yankaskas said. "Collectively they went through 1,053 tanks of air - more than a diving resort would go through in a month."

This year's competition saw many great advances in design and technology – "one team set a record, but all teams showed teamwork and ingenuity," said Charlotte George, NSWCCD naval architect in the Naval Architecture and Engineering Department, who acts as chief



Navy divers tread water at the 13th International Human-Powered Submarine Races in the David Taylor Model Basin at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 24, 2015. (U.S. Navy photo by Ryan Hanyok/Released)

liaison between Carderock leadership and the FURE.

She graduated from Florida Atlantic University (FAU) with a bachelor's degree in ocean engineering in 2012. While at FAU, she was a strong supporter of STEM outreach, which eventually spawned her involvement with the human-powered submarine races.

"I am especially proud to be a part of this international event," George said. "When I was an FAU student, I participated in the ISR and it piqued my interest in interning and working full time at Carderock." She hopes the submarine races will inspire participants to follow in her footsteps.

"Our mission is to inspire students of the various engineering disciplines to delve into broad areas of underwater technology advancement and to provide them an educational experience that translates their theoretical knowledge into reality," said FURE founder Nancy Hussey. "We foster advances in subsea vehicles and increase public awareness of the challenges individuals face in working in and exploring the ocean depths."

The race is managed by the ISR Organization, a group of volunteers who have dedicated their personal talents and abilities to maintain the continuity of this unique technology competition. This organization operates with support from corporate sponsors, government and academic officials and a host of private individuals.

In addition to the submarine teams bringing their ideas to fruition, the teams wear scuba gear to compete in the various water categories, while U.S. Navy divers from Naval Surface Warfare Center Indian Head Explosive Ordnance Disposal Technology Division provided water safety and underwater support to ensure the competitors safety. "I am proud to be a part of a team that keeps not only our Sailors safe in support of the warfighter, but our ISR contestants as well," George said.

Awards

At the end of the week-long competition, the winning teams were recognized for best overall performance, innovation, absolute and fastest speed, best design outline, smooth operator and best spirit of the races. This year, teams from the United States, Canada, the United Kingdom, Germany, the Netherlands, New Zealand and Oman competed.

Overall performance: Omer 9 submarine team from Ecole de Technologie Superieure located in Montreal Quebec, Canada. The ranking of overall performance is determined by quantifying the Figure of Merit (FOM) for each team and submarine. Seventeen weighted parameters were ranked to determine the FOM. The analysis included aspects of other awards and the team's attitude, persistence and resourcefulness. Ecole de Technologie Superieure team members: Pascal Seguin, Michael Demers, Guillaume Fortin-Moquin, Jordan Gagnon, Hugo Saint-Gaudens, Noe Peres, Geoffrey Le Roy, Renaud Simard-Bouilianne, Anthony De Marco, Didier Lalonde-Dupuy and Raphael Mercier.

Innovation: Warwick University's HPS Godiva submarine team located in Coventry, United Kingdom, recognizing the submarine team from any design category that incorporated the most innovative design, construction and/or performance attribute. Warwick University team members: Verity Armstrong, Rupert Barnard, Sam Clifton, Jack Fairweather, Richard Freeman, Theo Saville, Matt Shanahan and Stuart Snow.

Absolute speed award: Delft University of Technology located in Delft, Netherlands, who placed first at a record breaking 7.42 knots in their WASUB 5 one-person propelled submersible. Delft University team members: Ruben de Nie, Ramon van der Valk, Tom Zevenhoven, Duke Spaans, Marjolein ten Hacken, David Zwart, Pieter van Altena, Emily Raijmaker, Tim van der Weide, Tim

Hageman, Tom Gulikers, Karthik Subramani, Anne Boijmans, Inge van Staalduinen, Isabel Brenner, Floor Boon, Lode Vancauwenbergh, Stefan Dirven, Jacob van Ooijen, Rico Hooijschuur, Bram Bronswijk, Bob van den Ende and Robert Braam.

Fastest speed by category: First, second and third place speed certificates were given to submarine teams in each design category.

Delft University of Technology located in Delft, Netherlands placed first at a record breaking 7.42 knots in their WASUB 5 one-person propelled submersible.

What Sub Dawg student submarine team from the University of Washington located in Seattle, Washington, propelled to second place at 6.01 knots.

The 12th Mantaray submarine team from Texas A&M located in College Station, Texas, took home third place at 5.8 knots. Texas A&M team members: Kevin Ariayanonthaka, Alyssa Bennett, Sarah Clark, Ashwin Gadgil, Martina Garcia, Hannah Huezo, Raylene Hylland, Amanda Massingill, David Patterson, Dylan Sanderson, Jacob Taylor, Melanie Tidwell, Ben Torrison, Lauren Waldron, Chris Williams and Colton Wylie.

The fastest high-school team was awarded to KIDS Team and Nautilus from southern Maryland. KIDS Team Nautilus team members: Teddy Schwalm, Abby Gerstman, Zaahid Ramakdawala, Ella Gerstman, Sam Carts, Lydia Kivrak, Andrew Kivrak, Liam Vincent, Scarlet Vincent, Maya Civil, Raphael Civil, Sophie Gerstman, Garrett Sullivan, Kaarli Lutz, Zahra Ramakdawala, Ava Leblanc, Giorgio Corica, Nico Corica, Garrett Hayes, Gavin Hayes, Nisha Lathrop, Justin Schwalm and Bryce Sullivan.

Best design outline: Delft University of Technology.

Smooth Operator Award: Jessie IV submarine team from Old Saybrook High School located in Old Saybrook, Connecticut, in recognition of their efficiency in staging for the race course, racing the course, troubleshooting as necessary and otherwise preparing for their next run.

Best spirit of the races: Nautilus submarine team from southern Maryland displayed the best gusto, fortitude, support for the other teams and overall best spirit. The winner was selected by the submarine teams themselves, and was awarded in memory of the late ISR contestant, Steve Barton of team Sublime.

"The United States needs scientists and engineers," Behrle said.

"There are multiple challenges in participating in ISR 13 - designing and building a submarine, getting to the event (six states and nine countries, including U.S.), getting to the starting line (214 starts) and crossing the finish line (83 completed runs)," said Yankaskas. "In the journey, the contestants come away with many new friends and professional contacts."

Submarine team members of "OMER 9" from Ecole de Technologie Superieure, Montreal, Canada, perform fine-tuning adjustments to their propeller system prior to their speed trial during the 13th International Human-Powered Submarine Races in the David Taylor Model Basin at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md., June 23, 2015. (U.S. Navy photo by Mass Communication Specialist 1st Class Clifford L.H. Davis/Released)

A powerful location: The Naval Ship Systems Engineering Station

By Dr. E. Michael Golda, NAVSSES chief technologist
Future Force Magazine: Summer 2015 edition

The DDG 1000 land-based test site provides experience with new ship systems going into the Zumwalt class. (U.S. Navy photo by Joseph Battista/Released)

Since the advent of electronics, U.S. Navy ships have steadily increased their use of energy to provide the additional power required by advances in sensors and weapons. A team composed of experts from the Navy, industry and academia is working to create and integrate new technologies into shipboard systems that satisfy these constantly increasing requirements. The Naval Ship Systems Engineering Station (NAVSSES) is a key member of this team. NAVSSES, a command within the Naval Surface Warfare Center Carderock Division, is the Navy's center for naval machinery for surface and undersea vehicles. The station's responsibilities span the entire machinery life cycle from concept through development and transition to acquisition, introduction to the fleet, in-service engineering support and disposal at the end of service life.

A trend of increasing power

To accomplish its mission, a warship's infrastructure of machinery and mission loads (sensors and weapons) must manage both energy (the potential to do work) and power (the rate at which energy is transferred). Since World War II, naval surface forces have exhibited a constant increase in the power requirements for each successive generation of shipboard mission loads as capabilities are improved and new technologies are introduced to meet warfighting requirements. There is nothing to suggest any change in the trend of increasing power requirements for mission loads for the next generation of surface combatants. In addition, providing power when and where needed will become more difficult, as these loads will be larger and nonlinear, stochastic (both random and variable) and pulsed. The capacity of traditional alternating current ship service generation and distribution systems can be increased by using larger generators at a higher voltage to provide additional power. While this approach is being used on the Arleigh Burke (DDG 51)-class Flight III, there are limitations caused by increasing power system size and weight.

In January 2000, the secretary of the Navy endorsed an alternative approach to meeting future shipboard power and energy needs—the integrated power system (IPS). By changing from a mechanical to an electrical propulsion system and taking advantage of advances in solid-state power electronics, a ship with IPS can make more effective use of its installed prime movers and use a common distribution system and advanced machinery controls to distribute electric power as required between machinery and mission loads. The Zumwalt

(DDG 1000)-class destroyer is the first Navy combatant to incorporate IPS. While this system has the flexibility to accommodate the new weapon systems of the last several years, the Navy may need to investigate medium- voltage, direct-current architectures to accommodate the continued increase in the requirement for shipboard power.

The development of shipboard power and energy technologies is a joint effort between the Navy, industry and academia. Major Navy participants include:

• The Office of Naval Research (ONR) Ship Systems and Engineering Research Division funds the basic and applied research and advanced technology development for shipboard electrical power generation, distribution, storage and control.

• The Electric Ships Office (PMS 320) of Program Executive Office Ships continues the maturation of successful ONR developments to ensure components and systems are available to meet the schedule of future acquisition programs.

• Within the Naval Sea Systems Command Naval Systems Engineering Directorate (SEA 05), the technical warrant holder for machinery and electrical systems, is accountable for setting the appropriate technical standards, ensuring safe and reliable operation, conducting effective and efficient systems engineering, and maintaining stewardship of the engineering and technical capabilities that support this technical area.

Developing and transitioning technology

NAVSSES's responsibilities are broad in scope and include: mechanical and electrical power and propulsion systems; auxiliary machinery systems; machinery automation, controls, sensors and networks; comprehensive logistical support; and machinery systems integration. The 1,500 scientists, engineers and skilled technicians of NAVSSES have the knowledge, skills, experience, facilities and equipment to conduct science and technology, research and development, test and evaluation, acquisition support, engineering, systems integration, in-service engineering and fleet support.

NAVSSES centralizes its machinery science and technology and research and development efforts in one division (Machinery Research and Silencing). This enhances efficiency by making it easier to develop and sustain personnel with in-depth technical expertise in naval machinery research by enabling them to focus on monitoring advances in fundamental science and actively participate in developing new technologies. With this expertise, these personnel can also provide technical leadership and respond to emergent Navy needs.

By routinely updating the Electrical Power Systems Life Cycle Master Plan, engineers provide fleet support can identify performance gaps and provide firsthand lessons learned on current components and systems to the scientists and engineers developing new technologies. Researchers and in-service engineers can work together to write clear and concise specifications to ensure the Navy acquires systems with the performance needed to meet warfighting requirements. The input of NAVSSES engineers during the industry design reviews helps identify and resolve technical issues early on, reducing program technical and financial risk. The full-scale testing facilities at NAVSSES provide a cost-effective venue to integrate and characterize a component or system before installation at the shipyard, both during construction and periodic modernizations during a ship's service life.

Exploratory development

The majority of NAVSSES technology development and transition efforts are funded by ONR, Naval Sea Systems Command, and various program executive offices. However, the Naval Innovation Science and Engineering Section 219 program authorized in 2009 provides the warfare centers with discretionary funding to be used as they direct to foster high-risk basic and applied research, develop programs to transition technologies to the fleet and support the development of workforce technical expertise. These funds are already making significant contributions to naval energy and power technologies, such as high-temperature superconductivity.

Superconductors are materials that lose all electrical resistance when maintained within an operating region bounded by a critical temperature, a critical current density and a critical magnetic flux. Metallic superconductors (low-temperature superconductors) became available in long lengths in the 1960s and resulted in the commercial development of magnetic resonance imaging. The absence of electrical resistance enables extremely power-dense machines. The Navy designed, fabricated and conducted an at-sea demonstration of a prototype superconducting generator and propulsion motor in the early 1980s. The need for liquid helium to cool the superconducting wire was a significant mechanical and logistical issue. The discovery in 1987 of ceramic superconductors that transitioned to the superconducting state at a higher temperature sparked a renewed Navy interest. Liquid helium was no longer required, and compact, commercially available mechanical refrigerators (cryocoolers) could provide the required cooling. ONR funded the development of a full-scale, high-temperature superconducting propulsion motor, which was tested at NAVSSES in 2009.

In 2004, ONR funded NAVSSES to evaluate the feasibility of reducing the weight of shipboard degaussing systems (which make ships less vulnerable to magnetic mines) by replacing the copper cables with superconductors. The study showed that even with the requirement for mechanical refrigerators, significant reductions in the system weight were possible. To accomplish this application, NAVSSES engineers developed and patented a design for a high-temperature superconducting system that used a gaseous cryogen for cooling the cable. Successful laboratory demonstrations validated the concept. ONR SwampWorks funded an at-sea demonstration aboard USS Higgins (DDG 76), during which the unit operated for more than 9,000 hours. To speed development in the components required in a cryogenic electrical system, such as cable connectors, circulation fans, temperature sensors and cryocoolers, NAVSSES engineers developed appropriate interface specifications and took full advantage of the innovative ideas from the Navy Small Business Innovation Research program to fund the design and fabrication. NAVSSES engineers were recognized by both the Naval Sea Systems Command and the Department of the Navy for their accomplishments.

NAVSSES is using Naval Innovation and Science and Engineering 219 funds to develop expertise in areas of high-temperature superconducting medium voltage distribution cables that are unique to naval applications, such as contact resistance and cryogenic dielectric materials. Additional basic research is being conducted to develop both a thermal model of a shipboard superconducting cable and an advanced cryogenic cooling concept.

Test and evaluation

Electrical rotating machines are key elements of a ship's power systems. Motors transform electrical to rotation mechanical energy to power machinery and propel the ship, while generators convert rotational mechanical energy into electrical energy. The power density of a generator can be increased by raising the rotational speed and voltage. In 2005, PMS 320 contracted with Curtiss- Wright's Electro-Mechanical Division to design and build a 14-megawatt, 7,000-rpm generator with a six-phase, 6,600-volt AC output. By using water-cooling circuits in the rotor field winding, the stator winding and the stator core, this developmental generator had a power density six times greater than a similarly sized low-speed, conventionally cooled generator.

NAVSSES constructed a test site that would permit full load testing of the generator. The test facility drivetrain uses a 3,600-rpm motor coupled to a speed-increasing gearbox to achieve the 7,000 rpm required by the generator. Following the generator's delivery in 2010, NAVSSES spent the next two years conducting the PMS 320 test plan before the program concluded. Based on lessons learned during this testing, NAVSSES engineers believed

As the Navy's center for electrical power and propulsion machinery, NAVSSES's responsibilities span the full life cycle of electric power technology.

there was additional engineering knowledge that could be gained by NAVSSES testing after the PMS 320 program concluded. Using Naval Innovation Science and Engineering 219 funds, NAVSSES engineers investigated and resolved vibration issues in the gearbox foundation. With continued funding in 2013, the test team conducted multiple eight-hour operational tests with outputs up to full load to investigate the performance of the water-cooling circuits at steady state temperatures.

The availability of Naval Innovation Science and Engineering 219 funding resulted in applied engineering knowledge that can be applied directly to the design of both future generators and the associated test sites. In addition, more than 20 junior engineers gained direct, hands-on experience in high-speed machinery analysis and operation.

System integration

New technologies only enhance Navy capabilities if they are successfully commissioned into service. NAVSSES has pioneered the use of the land-based test site (LBTS) to validate the design, manufacturability, and performance of full-scale machinery components and demonstrate the ability to integrate those components and controls into a system that meets Navy specifications. The LBTS can document full-scale system characteristics with production hardware and identify best practices to lower the risks of shipyard activation and trials. Additional benefits include the ability to provide training for the shipyard, precommissioning crew, and the NAVSSES engineers supporting trials and providing in-service engineering support. Since 1941, the Navy has evaluated 12 full-scale, surface ship propulsion systems at NAVSSES, either to reduce acquisition risk for a new ship class or to develop and demonstrate a new propulsion technology (including IPS). A single LBTS supported the development and maturation of IPS technology and its transition to the DDG 1000 IPS. The process began in 1995 with the integration of less-costly, smaller components and controls to create a Reduced-Scale Advanced Development IPS to validate the fundamental concept. Full-scale components, such as the main propulsion generator, were then manufactured and integrated as part of the Full-Scale Advanced Development IPS. Testing was completed in 1999 and provided the technical validation needed to select an IPS for DDG 1000. Following the award of the DDG 1000 contract, an engineering development model was installed, which successfully achieved both the design output torque of the propulsion motor and the predicted fuel consumption of the main turbine generator in 2005. Finally, one shaft set of the third production IPS ship- set was installed and tested at the LBTS between 2011 and 2013.

Summary

NAVSSES is a key member in the Navy, industry and academia team developing technologies to address the power and energy needs of future naval combatants and increase the capabilities of ships already in the fleet. As the Navy's center for electrical power and propulsion machinery, NAVSSES's responsibilities span the full life cycle of electric power technology. The organizational structure of NAVSSES and its extensive facilities and infrastructure provides a locale to integrate advanced machinery components into full-scale systems for test and evaluation, reducing program risk during transition to the fleet.

View article in Future Force Magazine at: http://futureforce.navylive.dodlive.mil/files/2015/08/FF-Summer-2015-web1.pdf

High-speed imaging tests on batteries to help in design of safe enclosures on Navy ships

By Joseph Battista, NAVSSES Public Affairs

Engineers at Naval Ship Systems Engineering Station, Naval Surface Warfare Center Carderock Division (NAVSSES) and researchers at New Mexico Institute of Mining and Technology (New Mexico Tech) began work to image gas expansion from failing lithium-ion cells through the use of high-speed schlieren imaging June 1 to help guide the design of safe battery enclosures on Navy ships.

The Office of Naval Research (ONR) funded project will give NAVSSES engineers a better understanding of rapid gas expansion generated by a catastrophic lithium-ion battery failure by using schlieren imaging. This type of high-speed video imaging allows engineers to make precise measurements of gradients in gas density in the vicinity of the failing cell. During failure, the cell may vent or explode, and if the resulting gas expands fast enough a shockwave forms as it moves away from the battery, which the schlieren imaging can quantify.

German physicist August Toepler developed schlieren photography in 1864 to study supersonic motion. Today's technique uses a single light source bounced off a mirror through the exploded subject, then off another mirror into a high speed video camera capable of capturing up to 250,000 frames per second.

Dr. Jason Ostanek, Naval Ship Systems Engineering Station mechanical engineer, poses with his Commander's Innovation Award with Vice Adm. Willy Hilarides, commander, Naval Sea Systems Command (NAVSEA), and Bill Deligne, executive director of NAVSEA in Washington, D.C., July 22, 2015. Ostanek earned his award for Innovative Methods for analyzing battery thermal characteristics. (U.S. Navy Photo by Scott Adam Webb/Released)

"Lithium-ion batteries are quite common – they are used in grid storage applications, electric vehicles, consumer electronics, a variety of military applications and even formula-one race cars," said Jason Ostanek, mechanical engineer with Energy Conversion Research and Development Branch at NAVSSES. "But the Navy will be using many batteries packed into enclosed spaces as part of the Multifunction Energy Storage Future Naval Capability (FNC). It's crucial for us to understand now what happens when a battery fails to learn how it might affect the other batteries in the space. Eventually we can use this data to develop lighter containers that can protect the other cells, while also being able to pack the cells closer together."

New Mexico Tech researchers are electrically and thermally abusing the batteries to the point of failure to create a pressure release explosion in a laboratory environment. Dr. Michael Hargather leads the research team who hopes to quantify the amount of gas released, the gas release velocity and identify the presence of any shock waves produced in the battery failures. These data will be compared to dynamic pressure gage measurements and to parallel data generated at NAVSSES.

"We need to see what happens when the cell fails. We have data from pressure transducers, but schlieren imaging will provide additional information, such as directionality of the blast," said Ostanek, who earned his doctorate in mechanical engineering from Penn State University through the Department of Defense Science, Mathematics and Research for Transformation (SMART) Scholarship for Service program. SMART is a highly competitive program that pays for the students' education with a requirement to work at a Department of Defense agency for the equivalent of each year they are enrolled.

The high-speed camera visually captures density gradients and if present, captures the shockwave as it emanates away from the failed battery – providing information such as shockwave speed versus position. Engineers can also determine the track of any projectiles generated.

Ostanek said engineers at NSWCCD and Naval Surface Warfare Center Crane Division routinely fail batteries to qualify them for use.

"We already know that lithium-ion batteries can meet power and energy requirements for our applications, but we also need to make sure they are being deployed in a safe manner," Ostanek said.

Ostanek said Don Hoffman, the FNC program manager with ONR, was instrumental in securing funding for the research, and John Heinzel, senior chemical engineer with Energy Conversion Research and Development Branch at NAVSSES, provided his expertise on lithium-ion batteries to aid in the development of the research project.

On July 22, Ostanek received a Naval Sea Systems Command Commander's Award for Innovation for his work.

The U.S. Navy's Ship Model Program

By Dana Wegner, NSWCCD curator

The birth of the modern American steel Navy in 1883 was the result of the combined efforts of the executive and legislative branches of the federal government plus a considerable amount of public sentiment favoring a modern, high-tech Navy reflective of growing national pride. To justify funds spent and keep the positive momentum going, one of the ways the Navy promoted the expanding fleet was through the creation of large, highly detailed, scale models of each type of new ship. The models, originally built in house, were made at the same time the real ships were being planned and built. These exquisite, museum type official exhibition models were made solely as public relations pieces and, despite their size and intricacy, were stoutly constructed and capable of shipment to world fairs and commercial exhibitions nationwide to maximize their public exposure. Built to a standard scale of 1/48th actual size, early models ranged in size from about 5-feet long for a gunboat to about 10-feet long for a battleship.

A team of full-time government model builders employed by the Navy's Bureau of Construction and Repair located at the Washington Navy Yard, where the bureau designed ships and directed ship construction, built the earliest official models. The model-making group also made large hydrodynamic test models used in the Navy's 470-foot Experimental Model Basin and made aircraft models used in the Experimental Wind Tunnel, both located at the Washington yard. Models of each new type (class) of Navy ship continued to be made at Washington and then at other naval shipyards. In 1910, a key member of the government model-building group resigned and founded the first American commercial ship model building firm. Since 1982, contractors have made nearly all of the Navy's official ship models.

In 1940 several of the Navy's technical operations were reorganized and the Bureau of Construction became part of the new Bureau of Ships. By then, the bureau had accumulated and meticulously maintained about one hundred exhibition models which were displayed in the passageways of the temporary Navy buildings scattered over the National Mall in Washington. Shortly following the bombing of Pearl Harbor, President Franklin Roosevelt, a ship model builder himself, ordered the Navy models moved to the new David Taylor Model

Nineteen-foot Navy exhibition model of USS Alaska (CB 1) built by the New York Shipbuilding Corp., 1944. Here displayed at the Museum of Fine Arts Boston, 1945-46. (Photo provided by: NSWCCD Curator of Ship Models)

Basin located in a neighborhood known as "Carderock" on the banks of the Potomac River a few miles upstream from the city. Having been assistant secretary of the Navy (1913-1920), the president was well acquainted with the models and appreciated their irreplaceable historical value. The new model basin had vehicles and craftsmen qualified to move and repair the models and he believed that the location was more secure than downtown.

Dedicated in 1939, the David Taylor Model Basin features three tow tanks, or pools of water, under a single roof. The longest tank is 2,968-feet long. Large-scale models of ship hulls, both military and civilian, are towed through the water at precise speeds and the reactions of the models are measured and recorded allowing naval architects and engineers to predict the speed, seaworthiness, handling characteristics and efficiency of proposed hull designs. A National Historical Mechanical Engineering Landmark, the David Taylor Model Basin remains in constant use and has been supplemented by other towing basins, water channels and many other scientific facilities representing more than forty disciplines, making the Naval Surface Warfare Center, Carderock Division (NSWCCD), the Navy's primary resource for ship research, development, engineering, testing and evaluation. NSWCCD is a part of the Naval Sea Systems Command (NAVSEA), successor to the Bureau of Ships.

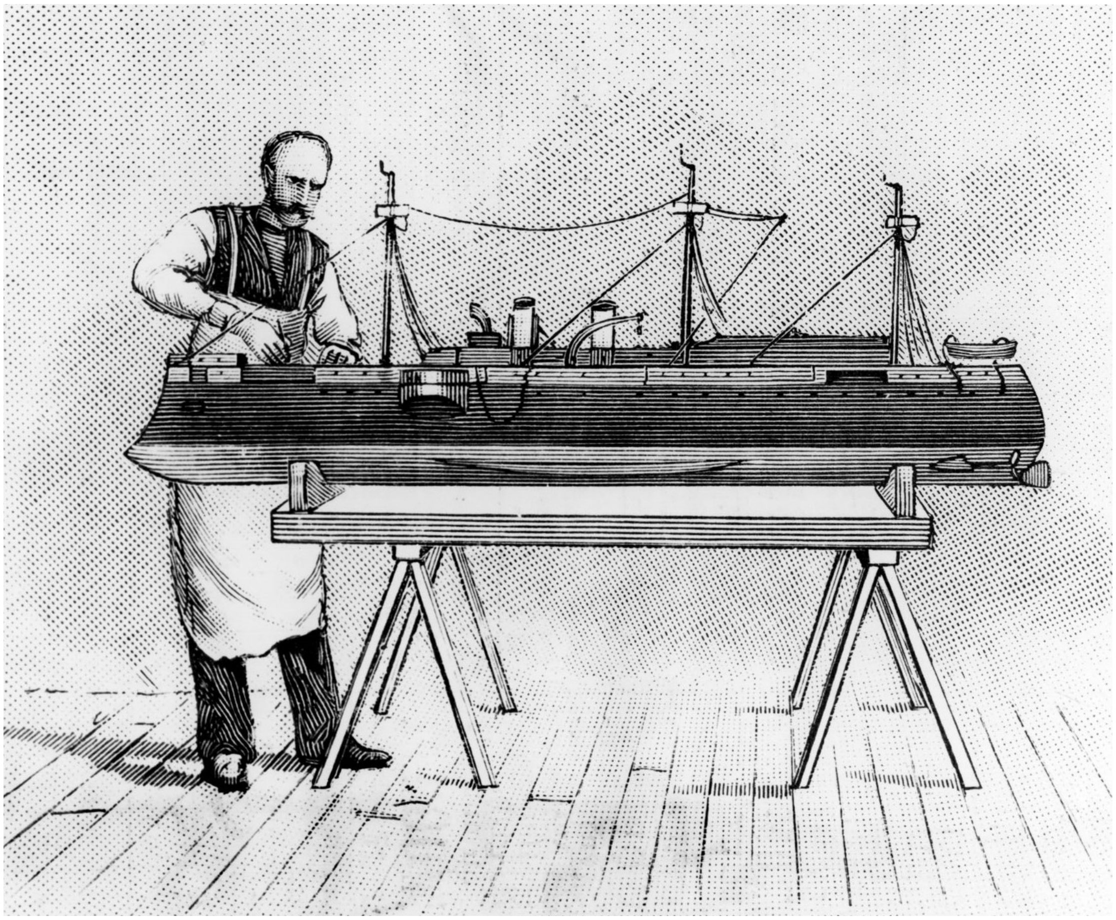
When the exhibition model collection began arriving at the David Taylor Model Basin in early 1942 it became apparent that the humid environment in the building enclosing the tow tank was harmful to the models, and the models tended to interfere with the important wartime work going on there. Consequently, they decided to distribute the models individually to naval facilities located inland, away from the coasts. This required, for the first time, a fully dedicated staff to select new sites, arrange transportation and monitor the condition of elements of the now far flung and dispersed collection. The Navy's official ship model collection has never been in the same place at the same time since 1942.

As the real U.S. fleet grew, so did the model collection, and the staff was expanded to 12 people who supervised the acquisition, quality, delivery and disposition of the more than 200 models accessioned during World War II. Each commercial or Navy yard model shop usually employed dozens of precision craftsmen who worked on single or multiple models for months or years. The Navy likes ship models and, at that time, spent lavishly when ordering examples of their new ships. Some of the wartime models are considered to be the finest examples of the ship modeler's craft ever witnessed in the U.S., perhaps in the world.

The position of curator of ship models was created in 1945 and has been staffed continuously since then. The first curator was a naval reservist but all subsequent incumbents have been Navy civilians. The current curator is only the fifth since the position was introduced. Staffed by four highly specialized Navy civilian professionals, the Office of the Curator of Ship Models today provides curatorial, conservation, registrarial and logistics services to NAVSEA. The command retains ownership of all of the models regardless of their age. Jointly sponsored by NSWCCD, NAVSEA and the Naval History and Heritage Center, the program office, ship model archives and conservation lab are still located at (actually under) the David Taylor Model Basin in the Carderock neighborhood of Bethesda, Maryland.

The policy of building, concurrent with the ship design phase, of at least one grand, large-scale model of each new type of Navy ship is still followed by NAVSEA. These big models of warships continue to speak eloquently and form the core of the current collection. The curator has the enviable position of overseeing the construction of new objects that will eventually become historical artifacts within his own collection. The Navy's official models follow a predictable three-stage life: They first represent a future or current shipbuilding project and are used for public and congressional relations. Following construction and commissioning of the real ship the model then represents a fleet asset and has additional value as a personnel recruiting tool. Lastly when the ship becomes razor blades, the model documents the history of Navy shipbuilding

Besides the large builder's models, parts of NAVSEA have acquired many highly detailed smaller models suitable for bookshelves or table tops, plus the program has accepted donations from ship model builders. The collection now numbers about 2,600 models, displayed in about 400 different places. The program has no museum of its own, very limited storage space, and following the policy begun in 1942, loans its models to qualified museums and to federal offices. In addition to state and local museums, display sites include the White House, Congress, State Department, National Museum of American History, presidential libraries, the Pentagon and the Navy's 10 official museums. Over 100 of the models spanning all eras may be seen at The Navy Museum at the Washington Navy Yard. For more information and images, please see: http://www.navsea.navy.mil/nswc/carderock/pub/cnsm.aspx.



Model maker at Office Force, (Bureau of) Construction and Repair Department at the Washington Navy Yard, 1898. (Photo courtesy of Courtesy Naval History and Heritage Command)

Navy engineers testing improved electronics grounding unit on USS Halsey to reduce shaft corrosion

By Joseph Battista, NAVSSES Public Affairs

The guided-missile destroyer USS Halsey (DDG 97) prepares to moor at Joint Base Pearl Harbor-Hickam following a seven-month deployment, Feb. 5, 2015. Halsey and its crew of nearly 280 Sailors conducted various theater security operations and goodwill activities with partner nations. Halsey also participated in cooperation afloat readiness and training, building partnerships to increase stability in the Indo-Asia Pacific region, and provided as an escort to both Carl Vinson and George Washington Strike Groups during Valiant Shield and Keen Sword exercises. (U.S. Navy photo by Mass Communication Specialist 2nd Class Johans Chavarro/Released)

During the week of July 6, engineers at Naval Surface Warfare Center Carderock Division (NSWCCD) in Philadelphia championed the installation and testing on USS Halsey (DDG 97) of a prototype electronics grounding unit (EGU) designed to actively monitor and control the amount of electric current on the propulsion shaft resulting in better control of current flow.

Development of this unit was part a fiscal 2010 Office of Naval Research Future Naval Capabilities (ONR FNC) effort titled "Corrosion and Corrosion Related Signature Technologies for Increased Operational Availability." Scientists at the Naval Research Laboratory (NRL) led the research and development effort of the prototype EGU.

The EGU is part of the Active Shaft Grounding System (ASGS) that includes an integrated shaft current sensing capability, electrical impedance to ground minimization, shaft current control capability and electrical contacts for rotating components.

"Attaching a rotating piece like a shaft to a hull creates electric current that could potentially cause a corrosion problem on a shaft," said David Fayocavitz, electrical engineer with Corrosion and Coatings Engineering Branch.

Expectations are that this new EGU will provide Navy engineers with improved system function and control, which will allow them to determine what adjustments to make to the EGU to reduce the possibility of shaft corrosion. The current generation of EGU, does not record data and is limited in its ability to adjust and control the electrical current, which can change based on the ship's sea environment.

Fayocavitz and his colleague, engineer Bradley Lescarbeau, said extensive, and successful, laboratory testing of the prototype EGU, occurred at NRL in Key West, Florida, over the past few years resulting in a ship-ready prototype waiting for at-sea testing, but with no Navy vessel available to install it on until 2016. Then Fayocavitz got an email from USS Halsey's electronics maintenance officer requesting a replacement analog unit.

"We didn't have one available for them, and it would be 10 months before they could get a replacement," Fayocavitz said. He explained that the ship still functions without an operational analog EGU, but the shaft to hull current would be uncontrolled. "I saw this as an opportunity to install the ship-ready prototype and get real shipboard data on it. It was a win-win – they get a temporary EGU until the replacement is available and we get to test our prototype for 10 months before installing it permanently on the ship for which it was intended."

Fayocavitz explained that Halsey has two shafts versus the submarine planned for install of the EGU in 2016. The benefit – with two shafts, one using the analog EGU and the other the prototype, both EGU's performance in the same ship conditions will allow for an equal comparison.

Some advantages of the prototype are it is an enclosed unit and the elimination of maintenance requirements. Sailors will no longer need to make filter changes or clean the enclosed prototype because it is sealed from the elements. The analog units use an internal fan for cooling and thus are open to allow for air exchange. The prototype does not require active heat dissipation. Fayocavitz said they would monitor the performance of the prototype EGU to see if it works as it did on the test stand before moving it to its permanent ship.

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