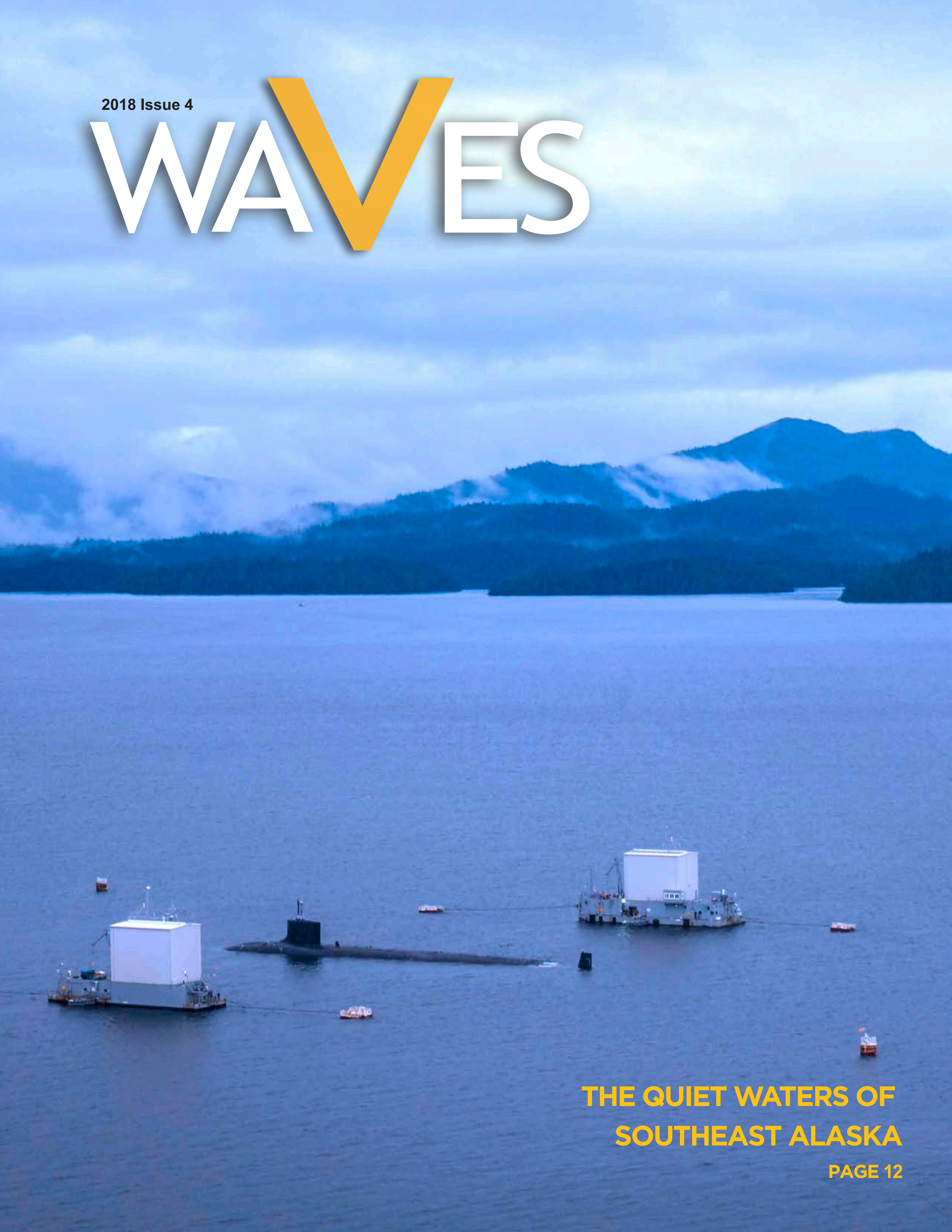
2018 Issue 4

WAVES



THE QUIET WATERS OF SOUTHEAST ALASKA

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Content

In this issue

As the technical director at Carderock, it is my goal to maintain our great reputation for innovation and technical excellence. When the Navy needs solutions to hard problems, they turn to Carderock.

Going forward, I want to keep a focus on Carderock's technical health. Obviously, one of the main priorities is our workforce - making sure we are not only hiring who we need, but providing them with the tools and the training to do their job, as well as recognizing them for the good work they do. Ship design is, of course, one of Carderock's primary technical capabilities, something we do well, so it deserves a spotlight. Equally important are platform integrity and performance, digital strategy, signature management and unmanned systems. I want to create a culture of innovation to rapidly create and adapt new technologies and processes that accelerate timely and affordable capabilities to the warfighter. Through all of it I will be focused on technical excellence – it is not enough to deliver the right answer, we must deliver it at the right time for the right budget for it to be relevant.

In this last issue of Waves for 2018, I hope you enjoy these articles from and about our workforce. I'm sure next year will bring more amazing things to Carderock.

Larry Tarasek

Team

Larry Tarasek
Katie Ellis-Warfield
Brooke Marquardt
Roxie Merritt
Monica McCoy
Kelley Stirling
Kevin Sykes
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Cover

The Virginia-class fast-attack submarine USS Texas (SSN 775) sits surfaced in Naval Surface Warfare Center, Carderock Division's Southeast Alaska Acoustic Measurement Facility (SEAFAC) static site on Oct. 26, 2018. (U.S. Navy photo by Monica McCoy/Released)

Spotlight
our people & work

Larry Tarasek
Carderock Division technical director

By Kelley Stirling, Carderock Division Public Affairs

Larry Tarasek (seated), technical director for Naval Surface Warfare Center, Carderock Division, signs the first technical excellence policy to better help Carderock employees and managers with project management on Oct. 12, 2018. With Tarasek are, from left, Dr. Chris Kent, chief engineer (CHENG) for the Naval Architecture and Engineering Department; Joan Shanahan, division quality director; and Lou Carl, Carderock's CHENG. (U.S. Navy photo by Nicholas Brezzell/Released)

Larry Tarasek began working at Naval Surface Warfare Center, Carderock Division in 1985 in what is now the Signatures Department. He never imagined at the time that he would be selected as the technical director.

When he first started as an engineer, Tarasek said the Navy was focusing on a new submarine design, Seawolf. He spent his first nine years doing submarine design and acoustics, traveling a lot to Carderock's Acoustic Research Detachment in Bayview, Idaho, running experiments. He said the Seawolf program had very stringent acoustic goals, and he and his coworkers put a lot of effort into meeting the requirements set for them.

"I'm an experimentalist at heart," Tarasek said. "It was a great time to come into Carderock and into the Navy."

When the Seawolf program didn't build as many ships as initially expected, Tarasek used the opportunity to do a three-year rotation at the Office of Naval Research (ONR), which broadened his technical experience from just signatures to overall submarine design, an experience he said he would recommend to any Carderock employee.

When it was time for him to return to Carderock, he decided to use the knowledge he gained at ONR to expand his base by joining what was then the Ship Design and Integration Department, where he did program management for the Virginia-class submarine and was a customer advocate for Virginia, the Ohio-class submarine and early concepts for Columbia-class.

Tarasek did this for about 15 years before moving into the front office as deputy technical director in 2011. In this position, he added surface ships and unmanned vehicles into his portfolio, as well as exposure to all the work being done in the detachments.

"Every day is different with different challenges," Tarasek said about working at Carderock.

Tarasek graduated from the State University of New York at Buffalo with a Bachelor of Science in mechanical engineering, a degree he said was an automatic choice since both of his older brothers had already forged that path, also at the same school.

One of his brothers had been working at Carderock already and as Tarasek neared graduation, his brother helped him get an interview. That brother went on to work for the Department of Defense in other capacities before retiring. His other brother is working in robotics in Rochester, New York, not too far from their hometown of Buffalo.

Now, as technical director, Tarasek said he looks forward to continue meeting with the workforce and sharing what's important to him and to Carderock. He said he plans to focus on technical execution of current projects, as well as strategic planning for "the Navy after next."

"I really want to be providing the Navy with the right designs for the ships of the future, and then service the fleet for the ships we have right now," Tarasek said.

He said there is strategic planning that has to happen that not only looks at five or 10 years down the road, but also looks at what's being done today.

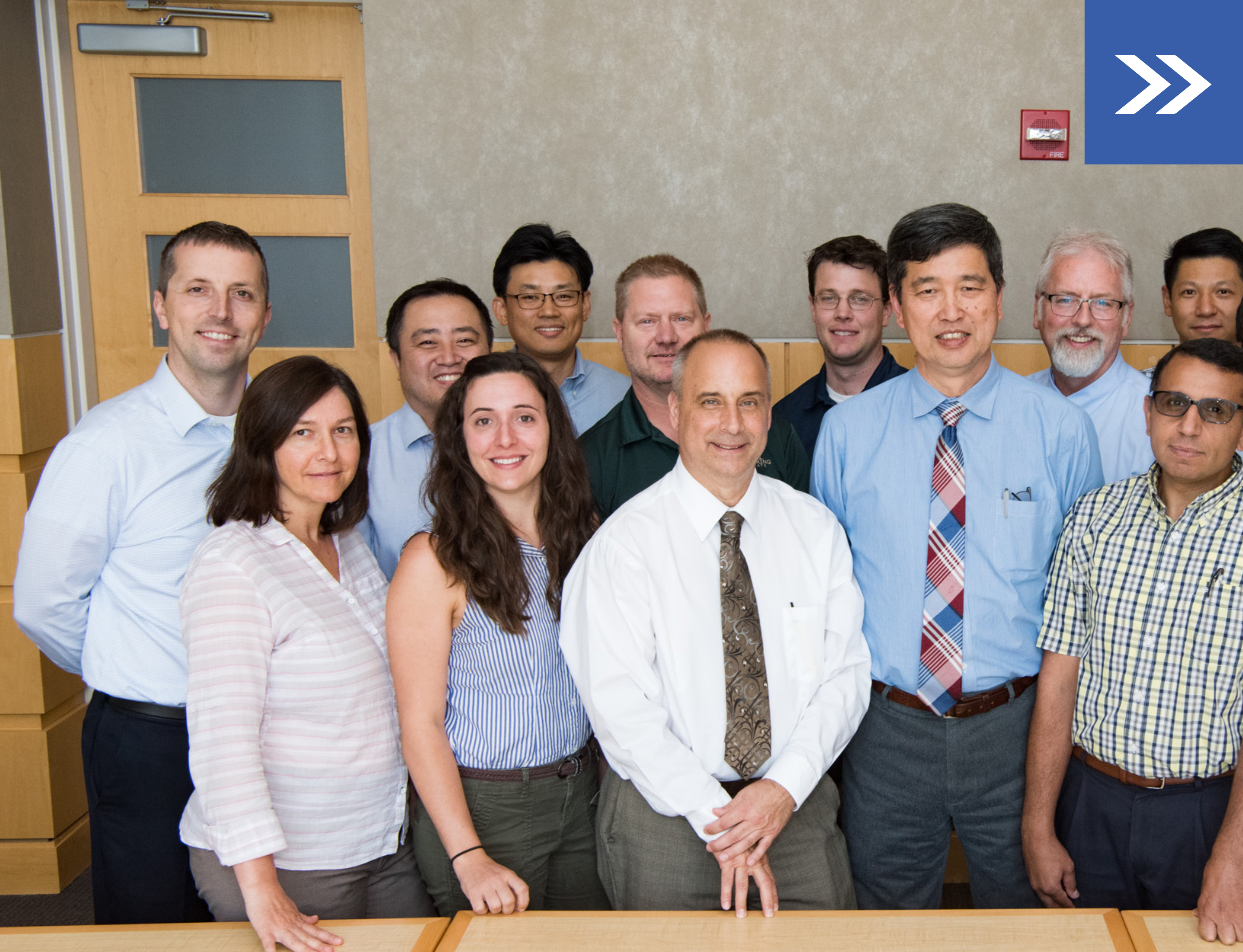
"We are at the peak of design for Columbia," Tarasek said. "But we're going to have a follow-on potentially to Virginia, so I have to think about what's the Navy after next, what's that next ship design going to look like."

To be ready, Tarasek said the core of Carderock's strategy should be ship design, unmanned systems, acoustic superiority, digital technology and platform integrity.

"The Navy's changing. Additive manufacturing, digital design – these are things that weren't relevant five years ago, they weren't part of the way we do things," Tarasek said, adding that first-class design capabilities, information technology and cyber are changing the way ships are designed and maintained. "And we have to prepare ourselves, and that's part of the strategic aspect."

He said he plans to do that by focusing on the workforce, the tools and facilities.

"Those are the things that are really important to me, that we have that infrastructure, to go and design that next generation of ships, submarines and unmanned vehicles," Tarasek said. "But it always starts with the workforce."



Summer Faculty Research Program

By Brooke Marquardt, Carderock Division Public Affairs

Through its education and outreach program, the Office of Naval Research (ONR) sponsors the Summer Faculty Research Program at Naval Surface Warfare Center, Carderock Division every year.

Carderock's director of research, Dr. Jack Price, said this program not only gives visiting professors an opportunity to provide their expertise and knowledge to different professional areas, but also allows them to gain some practical experience in naval problems. He also wants to see the faculty members act as recruiters for Carderock when they return to their respective schools.

"Having them here helps our researchers get in touch with an academic community, which is getting increasingly difficult to do. It's hard to get into the rest of the world and this gives them the opportunity to do that, to reach out into the academic community where some exciting research is going on," Price said. "We are looking to try to build a long-term relationship with these professors so that we can actually build good collaborations and a larger pool of potential candidates for employment."

Dr. George Youssef, assistant professor for the Experimental Mechanics Laboratory at San Diego State University, is one of several returning faculty members on base this summer.

"I'm working on formulating a novel design-analysis approach to help Carderock engineers to advance innovations in the area of 3D printing (additive manufacturing) realized structures. My research project is aimed at synthesizing the previously collected experimental data into mechanics of materials-based design approach for analysis of printed structures," Youssef said.

He said Carderock's faculty program bridges the gap between the faculty

Professors from the summer faculty program at Naval Surface Warfare Center, Carderock Division meet with Carderock leadership on July 10, 2018. Pictured, from left, front row: Dr. Gabriela Petculescu from the University of Louisiana at Lafayette; Charlotte George, Carderock's summer intern coordinator: Larry Tarasek, Carderock's deputy technical director; Dr. Paul Shang, Carderock's acting technical director; Dr. George Youssef from San Diego State University; and Dr. Judy Conley from Carderock. Second row: Drazen Hadzialic from Carderock; Dr. Sang Lee from Carderock; Dr. Troy Topping from California State University, Sacramento; Jack Templeton, Carderock's chief technology officer; Dr. Xiaofeng Liu from San Diego State University; and Dr. Jack Price, Carderock's director of research. Back row: Dr. Woo Hyoung Lee from the University of Central Florida; Dr. Jason Howison from The Citadel; and Dr. Jiajun Xu from the University of the District of Columbia. (U.S. Navy photo by Nicholas Brezzell/Released)

research interest and expertise and the Navy's research and development culture.

"It is an immersive program, where the faculty fellow works very closely with a Navy engineer or scientist on a project of common interest. The different expertise and perspectives are leveraged and enhanced at the end of each fellowship," Youssef said, adding that he often encourages students to apply for internships and other projects at Carderock.

In 2017, parts of Youssef's research led to a Carderock sponsorship to study the technical feasibility of rim-driven thruster for the propulsion of model ships. At the conclusion of the project, he and other researchers had substantially increased the readiness level of rim-driven thruster technology.

Dr. Woo Hyoung Lee, assistant professor in the Department of Civil, Environmental and Construction Engineering at the University of Central Florida (UCF) in Orlando, has been researching liquid waste management in Carderock's Wastewater Management Branch since 2014.

"Better understanding of physical and thermodynamic properties of bilge water emulsion will lead to developing and determining better solutions for effective emulsion treatment," Lee said.

Lee teaches three core undergraduate environmental engineering courses, as well as environmental biotechnology for graduate students.

"The classroom is a good place to share my experience at Carderock on how the fundamentals of what we learn can be used to solve the practical problems," Lee said.

One of the doctoral students in his lab has been working on emulsion projects for the past several years and will be joining Carderock as a postdoctoral researcher after his graduation this summer.

"Collaborating with Dr. Woo Hyoung Lee has been extremely valuable in expanding our basic research capabilities and opportunities," said Sang Lee, the technical area leader for oil pollution abatement (research, development, test and evaluation) for the Wastewater Management Branch. "Several joint research opportunities were a direct result from this ONR Summer Faculty Research Program. We plan to continue participating in this program with possibly other faculty members, while maintaining our established relationship with Dr. Lee and UCF."

From The Citadel School of Engineering, Dr. Jason Howison, assistant professor of mechanical engineering, is at Carderock working to develop a better understanding of the interaction between hydrodynamics and electrochemistry in the corrosion process.

"The Summer Faculty Program has been great for me to immerse myself daily in a research field that is half new for me. Being free from my administrative and teaching duties has enabled me to make great progress in learning new software and broadening my understanding of materials and corrosion," Howison said.

When he goes back to The Citadel to teach, he said, "It's exciting for me to draw from new experiences to keep my lectures up to date, and students respond well to current research and applications being brought into their courses."

Dr. Gabriela Petculescu from the University of Louisiana at Lafayette has been working with Carderock Division's magnetic materials group since 2008.

"It has been excellent for me. It is a period that I totally dedicate to specific projects, a time when a lot gets done," she said. "Further, the collaborative and creative environment in the group is very stimulating. As a group, we were more able to find answers to intricate problems."

In the near future, Price is looking to expand the program, which he says provides the participants potential employment and gives Carderock a look into the new engineers, mathematicians and scientists it needs to replace an aging workforce.

"Making these connections moves the field forward. It's exciting to see, and that's what I love about the program," Price said.

The following pages include information and research by each of the visiting faculty members.

Aerodynamics, aeroelasticity, and the harmonic balance method

Jason Howison, Ph.D.

Dr. Howison is an assistant professor in the Department of Mechanical Engineering at The Citadel. Dr. Howison received his doctorate in aerospace engineering from the University of Tennessee in 2015.

His current research interests are computational fluid dynamics, turbulence and transition modeling, and aerodynamics and aeroelasticity of wind turbine blades. He is also a registered professional engineer in South Carolina, and has worked in the design and analysis of solid rocket motor ballistics.

Research abstract

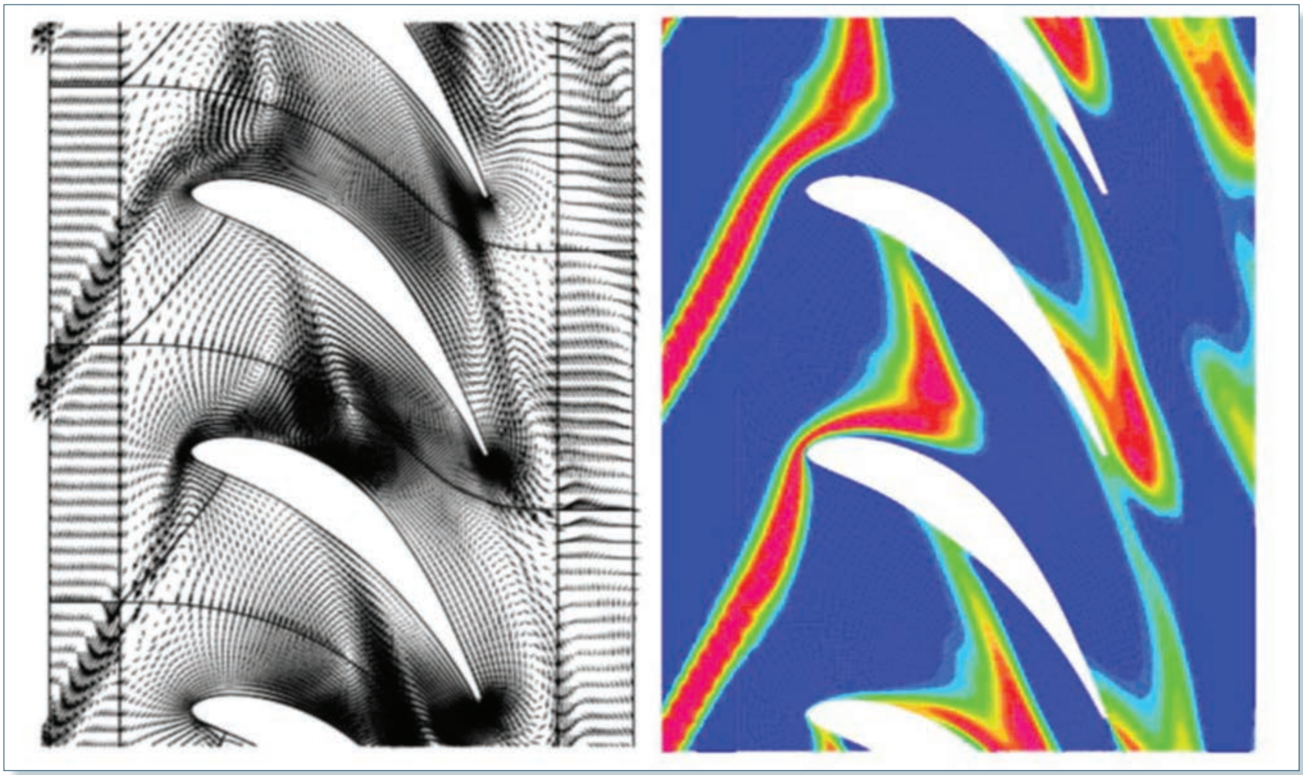
For his Summer Faculty Program Project, Howison explored aerodynamics, aeroelasticity and the harmonic balance method.

Most current wind turbine aeroelastic codes rely on blade element momentum method with empirical corrections to compute aerodynamic forces on the blades. While efficient, this method relies on experimental data and does not allow designers much flexibility for alternative blade designs.

Unsteady solutions to the Navier-Stokes equations offer a significant improvement in aerodynamic modeling, but these are currently too computationally expensive to be useful in a design setting. However, steady solutions to Navier-Stokes equations are possible with reasonable computation times.

The harmonic balance method provides a way to represent unsteady, periodic flows through a coupled set of steady-state solutions. This method offers the possibility of unsteady flow solutions at a computational cost on the order of a few steady-state solutions. By coupling a harmonic balance driven aerodynamic model with a mode shape-based structural dynamics model, an efficient aeroelastic model for a wind-turbine blade driven by Navier-Stokes equations will be presented.

The impact of the Spalart-Allmaras turbulence model and gamma-Re_theta-t transition model on aerodynamics will be explored as will flutter onset of 1.5 MW WindPACT wind-turbine blade.



Smart water and wastewater management: FUTURe CITy

Woo Hyoung Lee, Ph.D., P.E.

Dr. Lee is an assistant professor in the Department of Civil, Environmental and Construction Engineering at the University of Central Florida (UCF). He received his doctorate in environmental engineering from the University of Cincinnati in 2009.

Prior to joining UCF in 2013, he worked for U.S. Environmental Protection Agency's National Risk Management Research Laboratory as a post-doctoral associate.

His primary research area is developing electrochemical microsensors for in situ investigation of physical and chemical dynamics in microenvironments (e.g., biofilm, corrosion, emulsions or plant) by combining with nano and biotechnology.

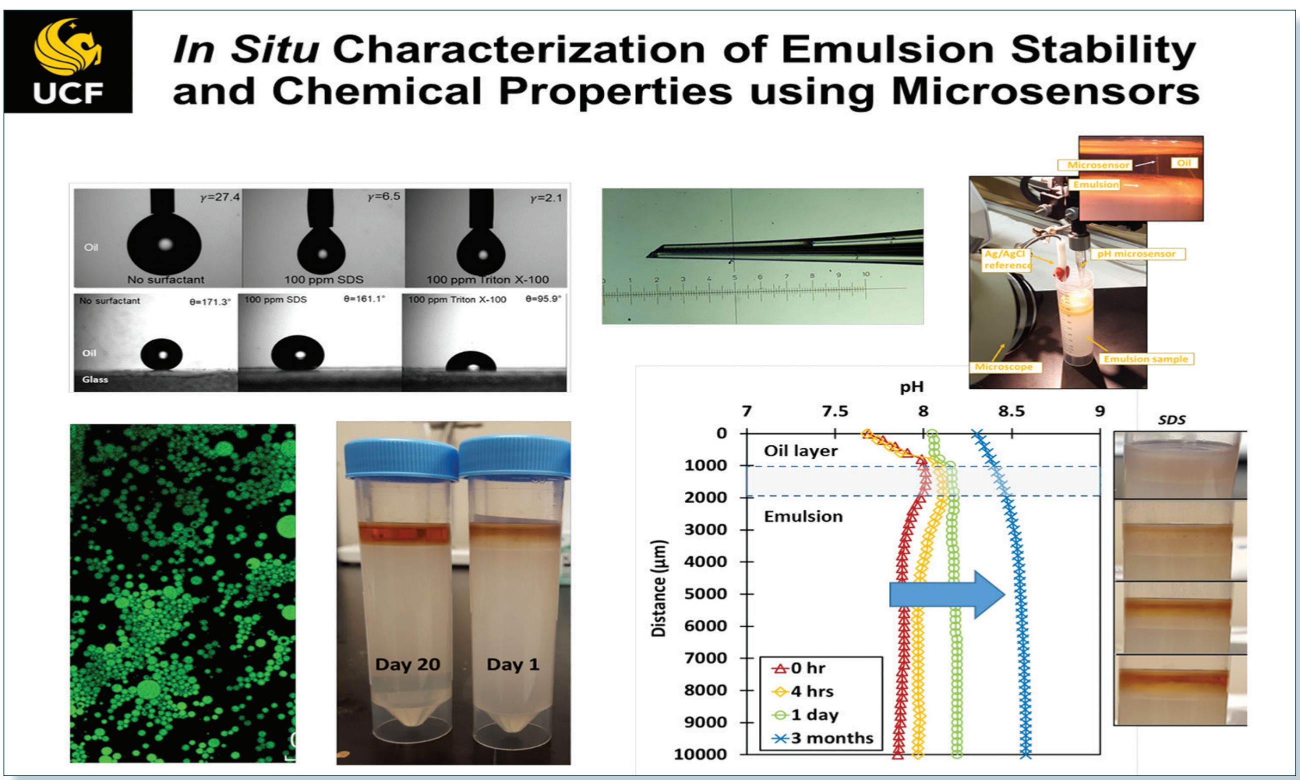
His other research interest is developing renewable (bio)energy processes for environmental sustainability. He is currently a registered professional engineer.

Research abstract

Fostering smart urban transformation and ubiquitous resilience with connected infrastructure and technology (FUTURe CITy) initiative at UCF is a group of researchers who have a vision to synergistically explore wide-ranging technological advances towards better serving urban residents.

As the human population increases and environmental requirements become more stringent, the need for sustainable water management treatment systems that meet regulatory standards and reduce energy consumption has become a top priority in the water industry. In addition, renewable energy production from waste is one of the major components in futuristic cities.

Lee's Summer Faculty Program Project explored novel technologies and their applications for sustainable water and wastewater management and renewable energy productions. These include a novel symbiotic microalgae-bacterial process for advanced wastewater treatment, renewable microalgal biohydrogen production from wastewater, microbial fuel cells (MFCs) technology for oily wastewater treatment, microsensors for understanding lead leaching events, heavy metal detection sensors for groundwater and mining wastewater, superhydrophobic MoS2 sponge for oil separation and silica-quaternary ammonium nanocoating for harmful algal bloom control and water disinfection.



Nontraditional uses of resonant ultrasound spectroscopy:

Heat exposure history, homogeneity and variability in 3D-printed metals

Gabriela Petculescu, Ph.D.

Dr. Petculescu is an associate professor at the University of Louisiana, Lafayette.

She received a bachelor of science from University of Bucharest, Romania, in 1995. In 2002, she earned her doctorate in physics from Ohio University.

Petculescu then had two separate, two year postdoc appoints: 2002 at National Center for Physical Acoustics, Mississippi, and 2004 at Northwestern University, Illinois. She has been an assistant/associate professor in physics since 2006 and a participant in the Summer Faculty Program at NSWC Carderock Division in the Magnetic Materials Group (Code 612) since 2007.

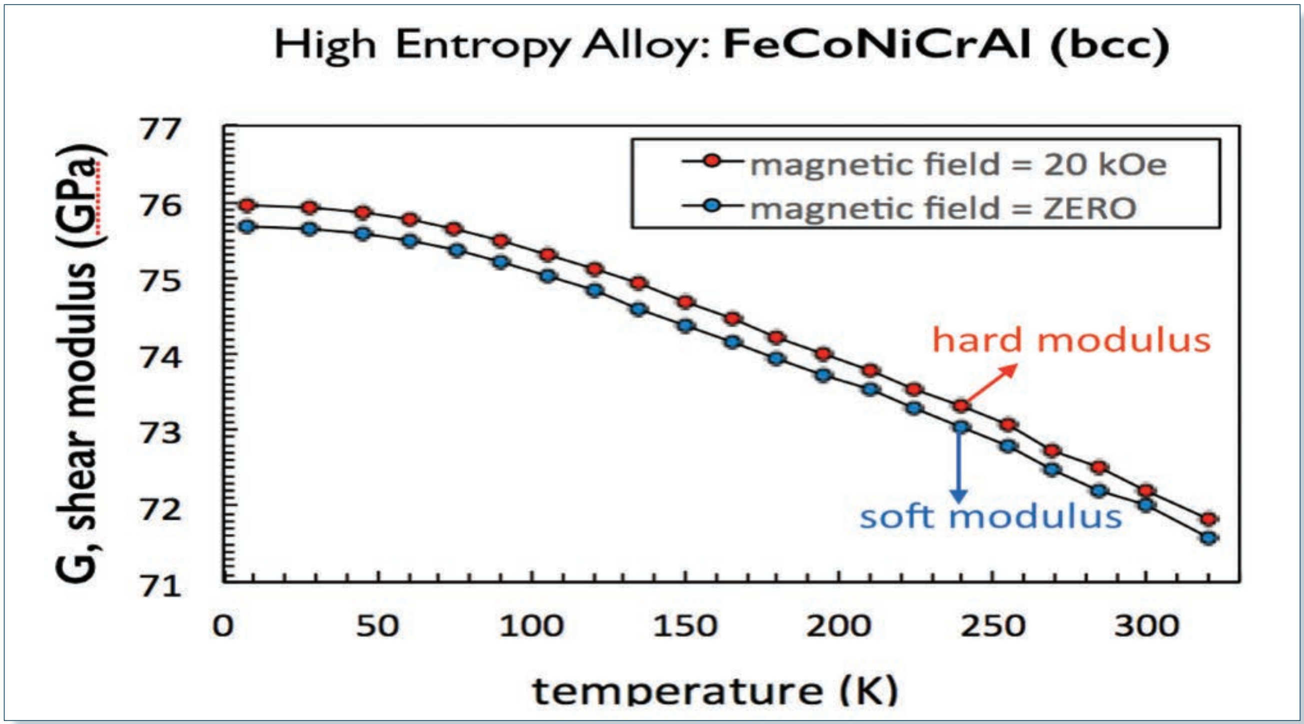
Petculescu's research focus is working at the interface between physical acoustics and material science by using ultrasonic techniques to understand properties of materials and their potential applications.

Research abstract

The modern technique of resonant ultrasound spectroscopy (RUS) has been traditionally used for measuring elastic properties of solids under various environments (temperature, pressure, and magnetic field).

These measurements can be used to elucidate fundamental phenomena such as phase transitions, strong magnetoelastic coupling, anharmonic effects, etc., that occur in various materials. All have been proven valuable in characterization of newly developed alloys.

The focus of Petculescu's Summer Faculty Program Project explored how recent studies showing how RUS can have yet another use: determining a materials' heat exposure history (Fe98Ni2, Fe98Co2); evaluating phase homogeneity and elasticity of high entropy alloys (HEAs) FeCoNiCrX; or assessing binding in 3D-printed metals (Fe90Ni10, Fe70Co30).



Data-driven quantification of model uncertainty

Vladas Pipiras, Ph.D.

Dr. Pipiras earned his doctorate in mathematics and statistics from Boston University in 2002.

He has since been with Department of Statistics and Operations Research at University of North Carolina, Chapel Hill, rising to full professor in 2012.

His main research interest focuses on time series analysis, extreme values and sampling. His publication list includes three books and more than 60 journal papers.

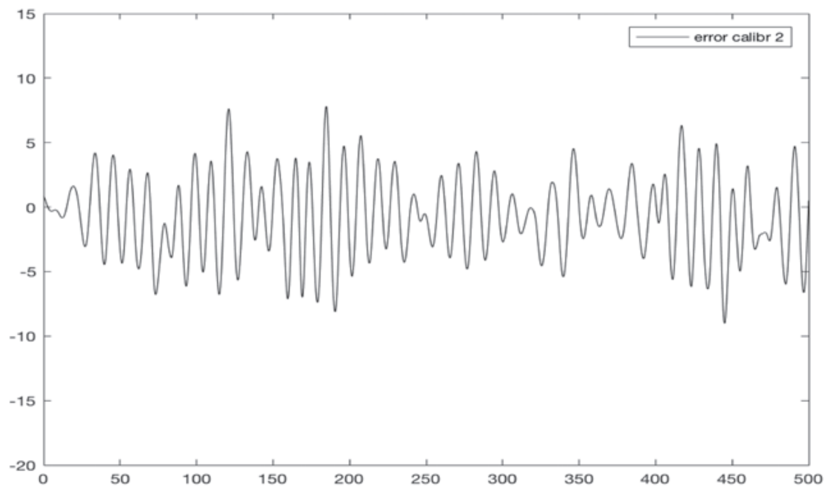
Research abstract

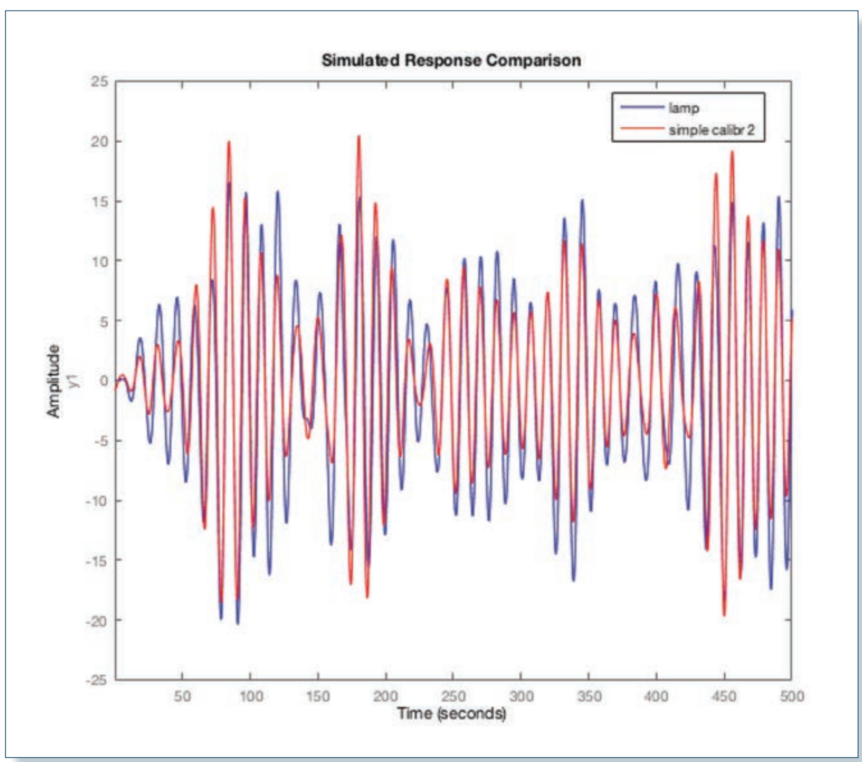
When studying random phenomena of interest, examining data from multiple sources (models) is common practice. For example, ship motions or loads data can be collected from a model basin or sea trials, or generated from various computer programs (e.g. SimpleCode, LAMP).

Some basic questions then include, "How should different estimates of the same quantities of interest obtained across multiple models be interpreted?" and, "If one of the models is less 'expensive' to run, how can it be used in conjunction with the more expensive models to better estimate the quantities of interest?"

Pipiras' Summer Faculty Program Project explored several approaches to such questions from the data perspective. A distinction will be made between non-rare problems (e.g. mean estimation) and rare-problems (e.g. exceedance probability estimation).

Connections to the multi-fidelity estimation will be drawn for non-rare problems, and bivariate extreme value theory will be advocated for rare problems.





A rigorous link between hull geometry and extreme event statistics

Themistoklis Sapsis , Ph.D.

Dr. Sapsis is the Doherty associate professor of mechanical and ocean engineering at Massachusetts Institute of Technology (MIT), where he has been faculty since 2013.

He received a diploma from Technical University of Athens, Greece, and a doctorate in mechanical engineering from MIT.

Before becoming faculty at MIT, he was appointed research scientist at Courant Institute of Mathematical Sciences, New York University, where he worked on stochastic methods for turbulence.

Professor Sapsis' work lies on the interface of nonlinear dynamical systems, probabilistic modeling and data-driven methods. He has numerous contributions on the development of robust and efficient statistical prediction algorithms that take into account the challenges and constraints imposed by real world problems, primarily motivated by ocean engineering applications.

He has published in the areas of uncertainty quantification for turbulent fluid flows in engineering and geophysical systems and his methods and algorithms have been extensively adopted and applied by others in fields. A particular emphasis of his work is the formulation of mathematical methods for prediction and statistical quantification of extreme events in complex engineering and physical systems.

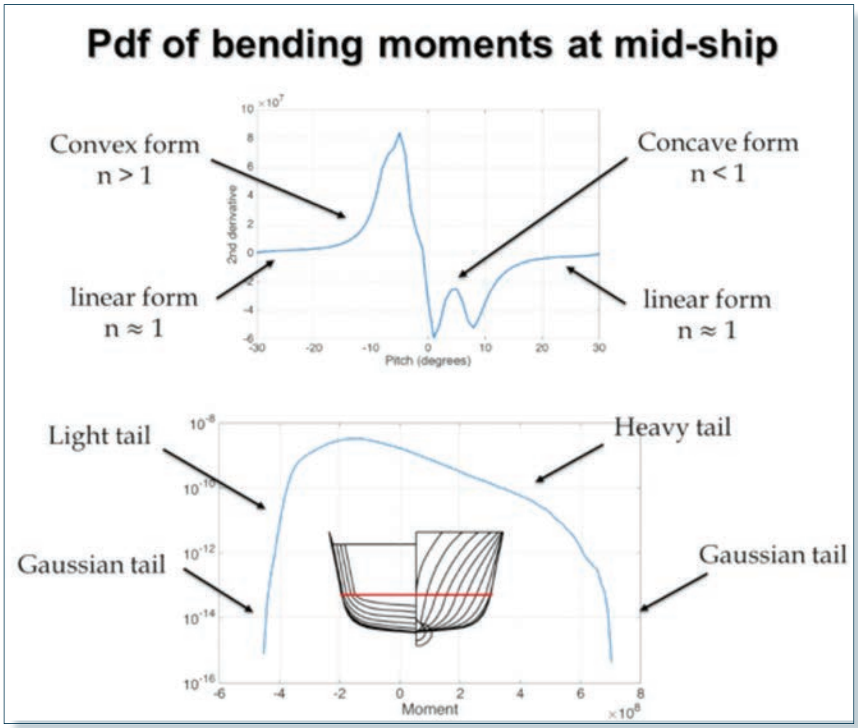
He is the recipient of three Young Investigator Awards (Navy, Army and Air Force research office), as well as the Alfred P. Sloan Foundation Award for Ocean Sciences.

Research abstract

Extreme events in ship motions and loads is one of the most important open problems in naval architecture, primarily because of their critical role in the safe operation of naval vessels. While numerous efforts, relying on linear methods or the Gaussian statistics assumption, have been devoted for quantification of extreme events in ship motions, the main challenge associated with them, still unexplored, is their rare and nonlinear character. From a mathematical view point, while there is a plethora of methods for systems with Gaussian characteristics, available mathematical methods for systems with non-Gaussian characteristics, like the ones observed in this context, are not yet well developed.

For his Summer Faculty Program Project, Sapsis explored prototype stochastic dynamical systems that are simple enough to be solved analytically and complex enough to capture non-trivial probabilistic character of ship motions and loads.

These prototype systems are formulated in terms of the hull geometric parameters (GZ curves) and provide analytically the asymptotic character of the tails for probability distributions of interest such as pitch motions and bending moments.



Spotlight
our people & work

Multi-physics modeling and simulation of thermal run-away in lithium-ion batteries and scalable thermal management methods

Jiajun Xu, Ph.D.

Dr. Xu is an associate professor in the Department of Mechanical Engineering at the University of District of Columbia. He earned his doctorate in mechanical engineering from University of Maryland-College Park.

His research interests include: 1) in-situ characterization and multiscale modeling of energy transport inside nanostructured materials; 2) thermal management and energy conversion using nanostructured materials; 3) in-situ monitoring and process optimization of direct metal laser sintering based additive manufacturing; and 4) environment-friendly water treatment using nanoparticle infused mesoporous materials.

His current research is sponsored by National Science Foundation, Department of Defense, Department of Energy and U.S. Department of Agriculture.

Research abstract

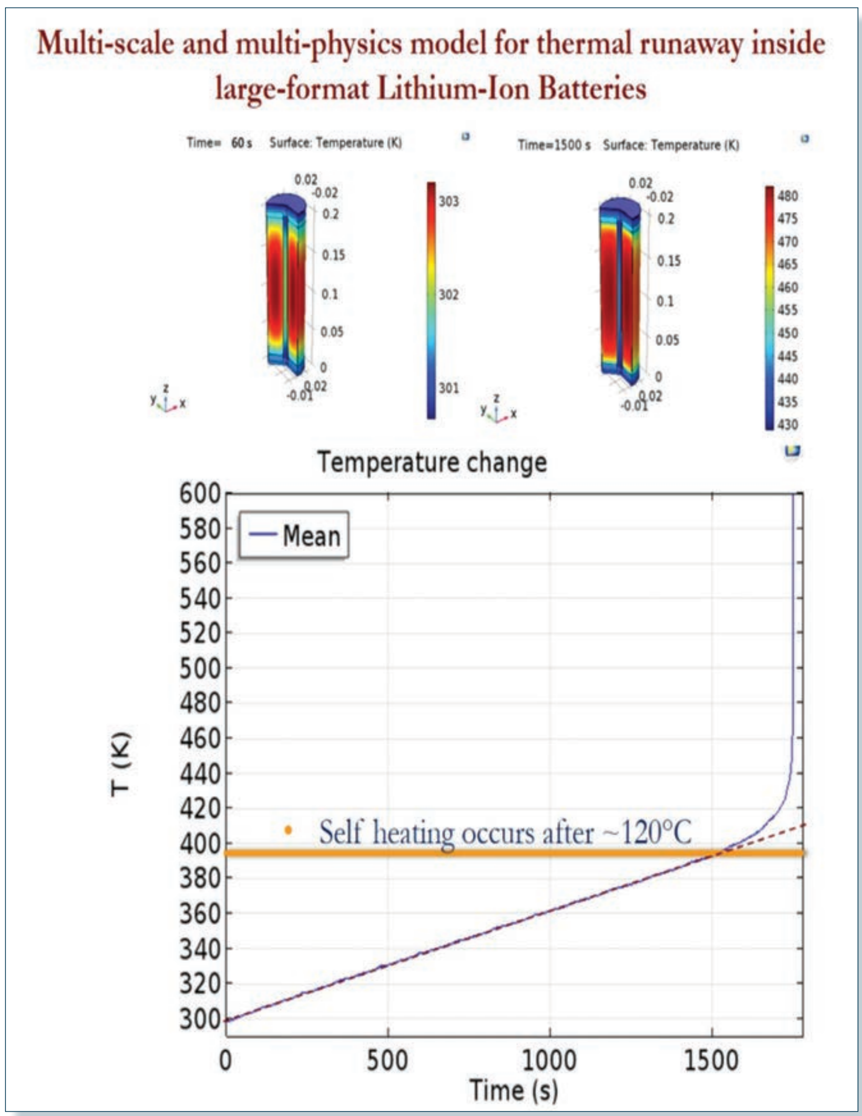
For his Summer Faculty Program Project, Xu explored recently developed multi-physics model (namely: electrochemical and thermal-mechanical processes) for simulating the thermal runway inside a lithium-ion battery using COMSOL software.

For electrochemical processes, the porous electrode theory was used with contributions coming from exothermic side reactions to model abuse mechanisms, which could lead to a thermal runaway.

For the thermal-mechanical processes, models of thermal abuse reactions that occur at specific elevated temperatures were used.

Prior experimental data on a large-scale lithium-ion battery tested at NSWC Carderock Division was used to construct and validate the model.

Xu also looked at current approaches to obtain a sophisticated understanding of the multi-scale and multi-phase thermal transport processes, and possible scalable and smart thermal management methods.



The quiet waters of southeast Alaska

By Kelley Stirling,
Carderock Division Public Affairs

Most people tire of their long commutes to work. Driving in a car in stop-and-go traffic for an hour can get old, but it's something that most people just get used to. In Ketchikan, Alaska, the commute to the Navy's Southeast Alaska Acoustic Measurement Facility (SEAFAC) is a little different; a 20-minute car ride, followed by a 10-minute boat ride to Back Island is what a person has to get used to.

"Rather than planes, trains and automobiles, it's planes, boats and cars," said Bill Fagan, head of the Trial Directors, Facilities and Mission Readiness Branch. Fagan himself works out of Naval Surface Warfare Center, Carderock Division's Bangor, Washington, site, which is responsible for the operation of SEAFAC. "It's fairly quick, fairly efficient, but a little different than your typical commute and needless to say, there is not much oncoming traffic."

Set at the edge of Behm Canal, the little bit of rocky beach SEAFAC sits on is a 15-acre parcel of a publicly accessible island. Naval Surface Warfare Center, Carderock Division leases the land from the U.S. Forest Service for the facility's operations. The rest of the 100-acre Back Island is home to a forest, offering an ideal location for boaters to stop and go for a hike, or Boy Scouts to go camping.

But the bread and butter of SEAFAC lies under the water a few miles away, right in the middle of Behm Canal, with two sites that service the U.S. Navy's Pacific Fleet of submarines. At the Static Site, suspension barges lower a submarine on cables and position it between measurement arrays to evaluate acoustic signatures of individual machinery components. The Underway Measurement Site provides the opportunity to collect acoustic signatures for a variety of speeds and operating conditions as the submarine transits back and forth between the dual bottom-mounted acoustic arrays.

Fagan said every Pacific Fleet submarine comes to SEAFAC about once every four years to get its acoustic health checked, which means they do about 12 to 15 acoustic trials a year, each taking, on average, about a week of testing.

"The acoustic check on a submarine is an opportunity to go in and check the submarine's acoustic signature, how much noise it's putting in the water, all the way from where it's just going 5 knots through flank bell (a ship's maximum speed)," Fagan said. "And the Static Site

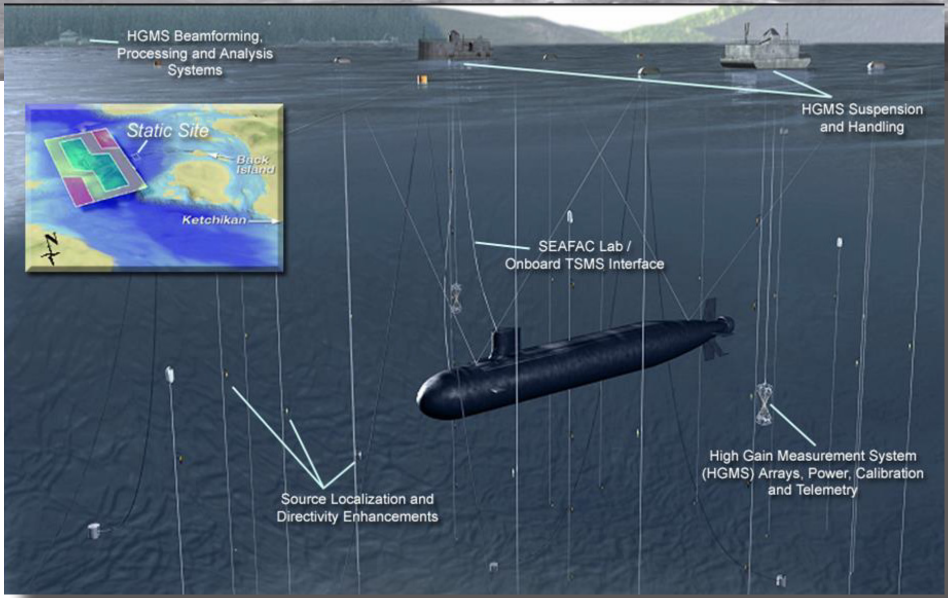
The Southeast Alaska Acoustic Measurement Facility (SEAFAC) operations building on Oct. 25, 2018, on Back Island off the coast of Ketchikan, Alaska. (U.S. Navy photo by Monica McCoy/Released)

is a place we can do unique testing on a submarine, where we can have complete control of it and be able to move it to just about any depth we want, to any position we want, any aspect we want, and be able to do testing very rapidly."

Jennifer Kelso, SEAFAC site manager who falls under Fagan's branch, said that while the primary mission of SEAFAC is to conduct submarine acoustic trials, they can occasionally accommodate other customers, such as hosting a rescue exercise, or even measuring acoustics of cruise ships.

"To have a stable environment, a controlled environment, where we can work with the assets gives us really unique capabilities within the Navy and here in southeast Alaska," said Kelso, who has been the site manager at SEAFAC for two years. But ultimately, she said it's all about the submarines.

In 2017, SEAFAC underwent a very complex array replacement that included the recovery and reinstallation of the both arrays and associated bottom-mounted anodes of the Static Site. Kelso gives credit to the contractors that work at SEAFAC for the hard work during this seven-week period. She said they have been instrumental in making so many of the evolutions safe, efficient and effective, whether it be site maintenance or a submarine trial.



Southeast Alaska Acoustic Measurement Facility (SEAFAC) static site. (Graphic provided/Released)

"Our number one priority in all these operations is always personnel safety, as well as environmental safety and then, of course, we are out here to collect good quality data," Kelso said. "But that's only after we come through our operational risk management and agree collectively as a team that we have a safe plan, something that's achievable with the resources available to us."

Prior to coming to SEAFAC, Kelso was a test director for large-scale acoustic testing in Carderock's Propulsor Development Group in West Bethesda, Maryland, just outside of Washington, D.C. She spent a lot of time in Bayview, Idaho, doing tests at Carderock's Acoustic Research Detachment, where she developed a love for the outdoors that also keeps her busy and happy in isolated Ketchikan.

A small boat operated by Naval Surface Warfare Center, Carderock Division's Southeast Alaska Acoustic Measurement Facility (SEAFAC) delivers Sailors and trial directors to Virginia-class fast-attack submarine USS Texas (SSN 775) on Oct. 26, 2018, as it sits surfaced in the SEAFAC Static Site off the coast of Ketchikan, Alaska. (U.S. Navy photo by Kelley Stirling/Released)

Behm Canal is a channel that separates Revillagigedo Island, where Ketchikan sits, from mainland Alaska's Cleveland Peninsula. The area is well-known for its salmon fishing, hunting and hiking, as well as the average 200 inches of rain it gets each year. Ketchikan itself is situated next to the Tongass National Forest. It is also a main hub for Alaskan cruise ships.

Fagan came to work for Carderock just a couple of years before SEAFAC was established in 1991. He said Carr Inlet Acoustic Range off Fox Island, Washington, became overcrowded and signature testing became difficult with the added noise nearby. Behm Canal's protected waters are deep and quiet, so it was the ideal spot to do unobstructed signature testing and get good quality data Fagan said.

SEAFAC uses a high-gain measurement system with twisted bi-cone arrays to focus acoustic energy on a ship, allowing the engineers to view the acoustic field at specified frequencies. The underway testing generally lasts for two days; the submarine can perform about two runs per hour and it allows them to quantify its acoustic signature as the ship moves between the arrays.

Communications between the boat and the operations center are limited during underway testing, unlike the testing at the Static Site. There, because the submarine is connected by cable and is stationary, the trial directors can also connect communications lines, greatly improving both voice and data communications between the laboratory and the analysts onboard the submarine.

Typically, in addition to Kelso, who is a government employee, there are about 12 contractors that work at SEAFAC supporting the mission on a daily basis. During a trial, an additional 19 engineers, analysts and trial directors come to SEAFAC, with 10 of them generally riding aboard the submarine throughout the test.

"SEAFAC is invaluable to the Navy," Fagan said. "Every submarine comes here, gets its acoustic health done, it's checked up, it's corrected if necessary. And when it goes out to sea, the Sailors aboard know that its acoustic posture is absolutely the best in the world, checked by the best in the world and ready to execute its mission in support of our nation."

Collaboration improves overall picture

By Justin Hodge,
Carderock Division Public Affairs

Ryan Hanyok, a science and technology photographer in the Visual Information Branch at Naval Surface Warfare Center, Carderock Division, was working on a demanding underwater test when he encountered a situation that would test his mettle.

"I needed to find a way to house a camera that could capture images at a rate of more than 1,000 frames per second, at varying angles, yet have the capability to sustain extreme hydro forces without getting wet," Hanyok said.

After some research, Hanyok realized he could develop a product that would fulfill the demanding requirements necessary and at a lower cost.

"I found and tested a variety of housings, but I was still encountering an issue with hydrodynamic forces at high speeds," Hanyok said. "So I started asking around, and was eventually able to come up with a concept that could be built in-house for much less, essentially saving the client money."

Hanyok teamed with Carl Baumann, a mechanical engineer, and Andrew Nowakowski, a naval architect, to come up with the above-mentioned concept to meet the project need.

The strut is a hemispherical dome attached to an arm-and-pulley system that can be raised and lowered into place for capturing underwater images. Inside the dome, a single cable linked to a portable computer powers a high-speed digital camera attached to a bracket capable of pivoting in numerous directions.

Finding the right solution to the problem wasn't easy, as they were working on a truncated timetable and lacked experience in a number of fields. The trio knew that collaboration among different departments was paramount to their success.

"Imaging department is unique because — although we are within the Corporate Communications Division — we work with people from all departments," Hanyok said. "I believe it was the collaborative efforts of the people within my network that made this project a success."

The three tapped the additive manufacturing group for materials and 3D printer capabilities to print variations of the camera bracket. They also spoke with engineers about fluid dynamics; the manufacturing and fabrications group for steel, aluminum and plastic components; and other experts about the right polymer to use, capable of withstanding hydrodynamic forces.

Hanyok said that although the team was able to develop a great solution, they did encounter a few setbacks.

Devin Pisner (left) and Neubar Kamalian (right), science and technology photographers in Naval Surface Warfare Center, Carderock Division's Visual Information Branch, look on as Ryan Hanyok explains the design of the "Hanyok Strut" in the David Taylor Model Basin in West Bethesda, Md. (Navy photo by Nick Brezzell/Released)

"One issue we had was that we 3D printed the fairing at the same time we were manufacturing the dome," Hanyok said. "Once both parts were completed we realized that the two did not match up as precisely as planned, so my thought was to use dental wax to fill the gaps. It would have been great if everything fit properly, but we worked with what we had to meet the deadline."

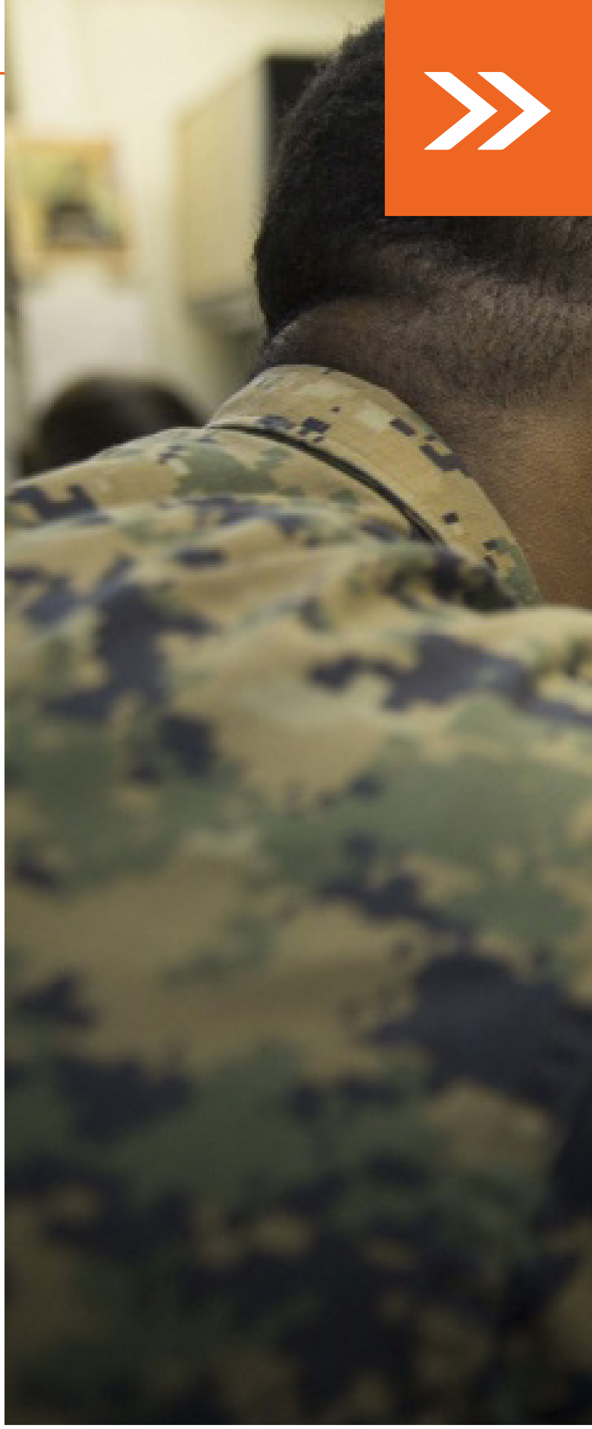
Hanyok said the new tool can be used on many platforms and carriages, and that he looks forward to seeing the different environments it can be tested in.

"We haven't tested it in open water yet, but I am always surprised what the engineers and scientists here at Carderock are asked to develop and test, so you never know what this design could be used for in the future," Hanyok said.

The strut has only been used for one test to date, but is scheduled for another test in the model basin later this summer.

Carderock engineers help Marines soar

By Justin Hodge, Carderock Division Public Affairs



A team of engineers from Naval Surface Warfare Center (NSWC), Carderock Division; Naval Sea Systems Command (NAVSEA) headquarters; NSWC Philadelphia Division; and Military Sealift Command (MSC) proved that being in the right place at the right time is vital to the mission of the fleet.

While participating in an annual Navy exercise in the Republic of Korea, Sam Pratt, a mechanical engineer with Carderock's Additive Manufacturing Project Office, didn't expect he would soon be working with a team of Marines, Sailors and naval engineers seeking a solution to what could have been a costly fix for a redlined F-35 airframe.

The week prior, Pratt was aboard USS Wasp (LHD 1) analyzing how 3D printers performed in shipboard conditions, while also training Marines of the Combat Logistics Battalion 31 (CLB 31), on Solidworks — a computer-aided design tool — when he was notified by the maintenance platoon officer that they were having issues with a replacement part for a landing gear door.

"I was with the maintenance platoon in South Korea training Marines from CLB 31 on the processes of drafting a design and how to apply it to printed items," Pratt said. "I was told they were having issues with printing a part needed to get the F 35 operational again. Their officer suggested teaming up to see what we could come up with as a whole, which turned out to be a great opportunity for collaboration."

Pratt said once they realized the issues they were facing it was fairly easy to find a solution.

"The Marines designed the part before I arrived, but were having sizing issues," Pratt said. "The 3D printer they had bought was a machine used primarily by hobbyists, which wasn't ideal for this type of project, but they were also using a free software tool called Blender, which is more typically used for special effects work to design movie and game characters. The software tool isn't really built for the types of accurate measurements needed for engineering since it is focused on artistic designs. I thought about how to design the part so it would fit and function properly."

The part in question was a small landing-gear component that mounts on the landing-gear door; as the landing gear door closes it presses the landing gear into the latch.

Pratt said it is good that the Marines were able to fix the issue when they did, in turn saving the fleet from incurring a hefty expense.

"It doesn't affect the landing gear or function of the plane directly, but eventually after continuous wear, the landing gear could begin to develop a rattle," Pratt said. "You can't buy the piece separate from the landing gear door which is a cost of $70,000. By having the capabilities to print in the field, we were able to replicate the part for a cost of roughly 9 cents."

The original part was plastic; the part that was manufactured by Carderock team was made of a material called Polyethylene Terephthalate Glycol (PETG).

To complete the task, Marines were able to take advantage of a new process for a field manufactured part which can be applied to a vehicle.

The deputy commandant for aviation in the Marine Corps worked on a policy for parts authorized to be installed on an aircraft that are not critical. Pratt was previously involved in this work, but it wasn't broadly known yet inside the Marine Corps.

The policy was just two days old when the group encountered their issue with producing a replacement part for the aircraft.

Pratt said the opportunity to work with the group on the tools and software was the most exciting part, but what ultimately allowed them to be successful was the policy.

"The biggest impact Carderock had for being out there was the policy for installing printed parts on vehicles," Pratt said. "On ground vehicles the policies are pretty straight forward. If it is not a critical part that will break the vehicle, then try to print an adequate replacement part for it. Aircrafts by nature are a lot more restrictive. There are airworthiness concerns, so when trying to print a part, you really have to know that the part is good so you don't put your pilots and flight crews in danger."

Sgt. Adrian Willis, a computer and telephone technician with Combat Logistics Battalion 31, 31st Marine Expeditionary Unit, prepares to print a 3D model aboard the USS Wasp (LHD 1) while underway in the Pacific Ocean, April 7, 2018. Marines with Combat Logistics Battalion 31, 31st Marine Expeditionary Unit, are now capable of additive manufacturing, also known as 3D printing, which is the technique of replicating digital 3D models as tangible objects. The 31st MEU partners with the Navy's Amphibious Squadron 11 to form the Wasp Amphibious Ready Group, a cohesive blue-green team capable of accomplishing a variety of missions across the Indo-Pacific. (U.S. Marine Corps photo by Cpl. Bernadette Wildes/Released)

Pratt believes this type of capability will be used more and more in the field since it offers the ability to get a vehicle back online that might otherwise take days or weeks to fix.

"We will see additive manufacturing used more often to make replacement parts," Pratt said. "There are already about 85 to 90 parts currently approved to print for ground vehicles, so it is as easy as going online, downloading the file and printing the part."

Marine Corps Systems Command (MCSC) maintains and approves each part submitted through the portal, Marine Maker, which houses the documents and specifications necessary to print a new part.

Many of the parts approved for printing are brackets, covers, caps and other items that tend to gradually become a problem over time, while other items are application specific tooling, like a wrench.

Pratt said in the field, the material selection is limited to five plastics ranging from stiff and brittle to tough and flexible that are easier for printers to handle, but there are a number of other materials currently being researched.
"We are working on getting more material capabilities out to the field, in particular the ability to print metal," Pratt said. "We can use it in a laboratory setting, but the machines aren't ready for the field yet. They are fragile, the materials are dangerous and it's generally challenging. Once this is possible it opens up a huge opportunity to print functional parts for vehicles."

Before returning stateside, Pratt and the group collaborated on a handful of other vehicle parts enabling the Marines to hone their skills and become more efficient in their processes.

The way of the future: 3D printing

By Mass Communication Specialist 1st Class Benjamin Wooddy, USS John C. Stennis (CVN 74) Public Affairs

On Aug. 24, 2018, the Arleigh Burke-class guided-missile destroyer USS Chung-Hoon (DDG 93) faced a problem that didn't have a quick solution: A bolt from a hangar-bay door roller assembly was stressed to the point of breaking, rendering the door unable to perform its basic task of opening and closing. In order for Chung-Hoon to get this one bolt, they would need to order a whole new roller assembly, which would take time Chung-Hoon didn't have.

Underway as part of Carrier Strike Group (CSG) 3, Chung-Hoon was in close proximity to the Nimitz-class aircraft carrier USS John C. Stennis (CVN 74) and its machinery repair shop that was beginning to use technology that could save Chung-Hoon both time and money.

Stennis' chief engineer, Cmdr. Kenneth Holland, and his team received a request from Chung-Hoon for a new bolt that would help repair the hangar bay door. Holland saw this as an excellent opportunity to use the 3D printer installed by Naval Sea Systems Command (NAVSEA) in April as part of a Deputy Chief of Naval Operations for Fleet Readiness and Logistics (OPNAV N4) additive-manufacturing acceleration initiative.

Engineers from Naval Surface Warfare Center (NSWC), Carderock Division, NSWC Philadelphia Division and Naval Undersea Warfare Center (NUWC), Keyport Division spent the past year working with Holland to install an advanced manufacturing laboratory (AML) on Stennis. As part of the overall NAVSEA afloat additive-manufacturing acceleration initiative taking place in fiscal years 2018-2019, their tasking is to install AMLs on three ships, and Stennis was the first.

This effort is the first official installation of additive manufacturing equipment shipboard, which required working through the Ship Change Document (SCD) process. The installation required electrical architecture updates, as well as the addition of filtration equipment and custom mounting to be fabricated. This was supported by NSWC Philadelphia engineers who went aboard Stennis to scan the space they would be using to create a 3D model so they could figure out how to arrange all the new equipment they would be getting. According to Nathan Desloover, an engineer with NSWC Carderock Division's Additive Manufacturing Project Office, they also developed a data-acquisition system that will be deployed to keep track of how the machines perform while recording environmental status, such as humidity and motion.

"This really is a requirements development effort," Desloover said of the NAVSEA project. "We are using that information to evaluate how these machines are working and what else we need to do to support the Sailors."

Holland said the printers are being used right now to resolve issues while they are small problems and to help manufacture parts that can generally only be obtained by purchasing the higher assembly.

Chung-Hoon sent over the broken bolt to Stennis where it was received by Machinery Repairman 1st Class Clinton Barlow. His objective was to design a bolt using 3D computer-aided design (CAD) modeling software that uses geometrical graphics to create digital replicas, which can then be used to create the actual part. But before creating any pieces, Barlow and his team had to be properly trained on this new equipment.

The Carderock and Keyport engineers went underway with the ship several times throughout the summer, not only maintaining the machines, but also offering training on how to use the equipment. Sailors also came to Keyport's headquarters, which is located just down the road of Stennis' homeport at Bremerton, Washington.

"When they came underway with us, it was our chance to get the machines dirty and see what they were made of," Machinery Repairman 3rd Class Blaine Matthews said.

The training allowed Barlow to create a manufactured replica that would then be sent back to Chung-Hoon to make sure that the newly created design would meet the specific requirements of the hangar-bay door assembly and allow the team back on Stennis to proceed with creating a new bolt from metal material with conventional manufacturing capabilities.

"We can replicate that bolt, send it to the ship, ask if it fits length wise, thread wise, and is this what you guys need us to make," Barlow said. "Instead of spending the time of cutting all that metal away, which can take up to six hours to do, I can print one and make the changes on the go."

Desloover said this was an innovative use of the additive manufacturing capability. By 3D printing several iterations of the bolt with cheaper material to get all the specifications perfect prior to machining the bolt, he said they saved both time and money.

The bolt from the Chung-Hoon is only an example of what the future holds for the capabilities of the 3D printer. Holland and his team have created other pieces

A 3D printed bolt, a broken bolt and the final manufactured bolt for a hangar bay door assembly sit from left to right on a 3D printer aboard the Nimitz-class aircraft carrier USS John C. Stennis (CVN 74) on Sept. 1, 2018. John C. Stennis is underway conducting routine operations in the U.S. 3rd Fleet area of operations. (U.S. Navy photo by Mass Communication Specialist 3rd Class Grant G. Grady/Released)

for systems that seem insignificant to most people but can effectively save the ship and the Navy money.

"For example, one of AIMD's (Aviation Intermediate Maintenance Department) calibration machines didn't work because they didn't have any knobs for it," Holland said. "We were able to manufacture a simple plastic knob and by creating that knob, although small, we were able to get that machine back up and running."

That single plastic knob, designed by Barlow and created by the 3D printer, ultimately saved the ship a substantial amount of money.

"They would've had to order a brand-new console which would've cost $5,300," Barlow said. "They brought me the knob, I designed it, put it on there and now they can use that piece of equipment which they use for hundreds of calibrations. They could've spent $5,300 on a new system or the 6 cents of material that it took to make that knob."

The process for creating some of these items can take as little as one hour. All a Sailor has to do is bring a sample of the part that needs to be created and submit a request, where it is then authorized by various members of the Engineering Department's chain of command, depending on the size and intricacy of the item. Once the request is approved, Barlow will break down the part using basic geometry and redesign that piece into the system. After the software renders the design, it is then sent to another program that splices the piece into various segments so that the printer understands how much to fill on the inside of the item for proper durability. Finally, the design is sent to the printer, which then uses plastic to create the item.

"It gives us another effective tool to keep the ship in the fight," Holland said. "It's also a tool to help us get first-time quality in the repairs for the ship. If you have something that works and it fits, forms, and functions, then you can deliver the final component and know that it'll fit."

Kelley Stirling, Carderock Division Public Affairs, contributed to this article.

Shock and its effect on the fleet:
Rear Adm. David Taylor naval architecture lecture

By Justin Hodge, Carderock Division Public Affairs

Innovation:
In Ship Design

The littoral combat ship USS Jackson (LCS 6) successfully completes the first of three scheduled full-ship shock trials in the Atlantic Ocean, June 10, 2016. (U.S. Navy photo by Mass Communication Specialist 2nd Class Michael Bevan/Released)

More than 50 navies around the world maintain an inventory of more than a quarter million sea mines, and the Navy needs to ensure crew and ship survivability under this very valid threat.

This was the driving point during the Rear Adm. David W. Taylor naval architecture lecture led by Joe Venne on May 17 at Navals Surface Warfare Center, Carderock Division in West Bethesda, Maryland. Venne is the program manager for Carderock's Underwater Explosives Test and Trials Program Office.

"Under shock, everything moves," Venne said. "The entire hull of the ship can move up several inches, and shock waves produce forces on equipment 20 to over 100 times the equipment weight. This gives you an idea of what the effect shock can have on ship equipment and also on the human body."

Since World War II, 15 U.S. Navy ships have been damaged by mines; 70 percent of ship damage during the Korean War was from mines, and three ships were damaged during the Gulf War due to mines.

Both allies and enemies to the U.S. are ramping up their production of sea mines in hopes of securing sea superiority, Venne said.

China is reportedly prepared to deploy more than 80,000 sea mines to protect against any potential conflict; and North Korea is developing nuclear sea mines to neutralize the U.S. and other countries in the event of a conflict.

These statistics are alarming to the U.S., but Venne said awareness and readiness will help ensure members of the Navy and the vessels underway are safe from these threats.

The U.S. Navy is becoming increasingly aware of the impact sea mines have on the success or failure of the mission, and continues to execute shock trials on newly designed ships to demonstrate mission capability in a combat environment.

"Shock-hardening requirements protect ships from threats and other extreme loadings events such as collision and groundings," Venne said. "Shock hardening is the only operational testing performed in an extreme dynamic environment."

Ship shock "trials" didn't take place until the 1980s, the first ship shock "test" was against USS Aggressive (MSO 422) in 1955.

"The value of the lessons learned from these ship shock tests resulted in the release of the naval instruction requiring all new construction of combatant ships successfully pass shock tests," Venne said.

The U.S. Navy policy states, "All surface commands shall ensure shock hardness is inherent in ship and equipment design, is validated by shock trials and is effectively maintained."

Although tests and trials are similar in that they both happen against operational ships, tests were more of a technically oriented exercise to define engineering problems, and trials are focused on demonstrating mission capability in a combat-shock environment.

The U.S. Navy has since taken a balanced approach to shock design, meaning the hull, equipment and crew must be equally survivable to support the mission.

This approach takes place through four steps: design, verification, validation and maintenance.

Shock trials subject fully manned and operational ships to increasingly severe non-contact underwater explosions, demonstrating the ability for mission success in a combat-shock environment.

Trials are conducted utilizing an operational scenario where one ship tows the charge while the test ship moves into place alongside the charge at the prescribed charge standoff distance for detonation. For combatant ships, a 10,000-pound charge is used, and a 40,000-pound charge is used for carriers.

After the charge is detonated, the ship's crew and the shock-trial team "fight through" the shock event, perform damage control as needed, restore mission systems to operational capability and follow up with an extensive engineering evaluation of the results of the shock.

The knowledge gained from shock trials is invaluable and continues to help the U.S. Navy move forward in its efforts to maintain superiority in at-sea operations, Venne said.

Billingsley talks preliminary surface ship design 2020

By Brooke Marquardt,
Carderock Division Public Affairs

Introduced as a “little bit of the past, a little bit of the future and lots of opinion,” Carderock hosted Daniel Billingsley, senior partner at Grey Ghost LLC and veteran of the Naval Sea Systems Command (NAVSEA), with a lecture titled, “Preliminary Design 2020: Everything Is New and the Same, But Old and Different.”

A 1969 graduate of Louisiana State University in Baton Rouge, Louisiana, with a degree in engineering science, Billingsley has 45 years of experience in leading, developing, implementing and applying computer tools to ship design for the U.S. Navy, Coast Guard and the marine industry. He played a key role in the development of design-process models associated with the Ship Design Process Workshop series, the STEP standards and is the author of numerous papers and articles on hull structure, computer-aided ship design and process improvement. After dedicating 38 years, Billingsley retired from NAVSEA.

In 2009, he was charged to write a paper about spending and design, where he likens the real estate slogan, “Location, location, location!” to what he suggests should be the Navy’s: “Money, money, money!” There never seems to be enough it.

“I got quotes from Congress that said our ships were too expensive. I got quotes from the Navy, the Department of Defense, and they all talked about cost, risks, schedule and cost performance schedule for these ships. And interestingly, several of them talked about an ineffective design process,” Billingsley said. “Navy leadership doesn’t really understand where ships come from … they don’t understand the leverage at the early stage of the design process has on cost, performance, quality and scheduling of ships.”

Billingsley expressed the need for more ship design engineers.

Money aside, Billingsley also went into detail about the relatively new computerized-design process, the need for collaboration and standardization across certain aspects.

“Computerized design and computerized engineering … we need to have standards about exchanging information between design tools and designers, but it’s a hard sell,” Billingsley said.

"There are a lot of things we wish we could do, we just don't have the funds," Billingsley said. He also expressed an interest, and need, for a process baseline model for budgetary needs and to illustrate the return on investments.

Billingsley concluded his lecture emphasizing standardization. Recalling the research he had previously done on process engineering, operator labor costs versus the cost of the tools, he said, "Operator labor costs will blow you away."

Billingsley said he cannot be quoted on exact numbers, but said that the Navy spends upwards of $13 billion dollars on office labor, and if it were to trim back by just one percent, they'd save approximately $130 million a year.

The Navy's most technologically advanced surface ship USS Zumwalt (DDG 1000) steams in formation with USS Independence (LCS 2) and USS Bunker Hill (CG 52) on the final leg of her three-month journey to her new homeport in San Diego, Dec. 8, 2016. (U.S. Navy Combat Camera photo by Petty Officer 1st Class Ace Rheaume/Released)

One bolt is all it took

By Kelley Stirling, Carderock Division Public Affairs

In the big scheme of designing a ship or a ship system, sometimes it comes down to one 9/16-inch bolt to prevent a problem.

That was the case when Naval Surface Warfare Center (NSWC), Crane Division needed help assessing at what sea state a certain piece of equipment could operate, so they reached out to NSWC Carderock Division on the advice of Reid McAllister, Carderock's director of integrated maritime mobility systems. This piece of equipment was basically an external trailer with a telescoping mast loaded with sensors.

"That's part of getting ready to go and do the trials. They have to go through this risk assessment and make sure it's all good and they can check it off," said Timothy Smith, head of the Simulations and Analysis Branch at Carderock.

In any system that is going to be installed on a ship, Smith said the researchers at Naval Sea Systems Command (NAVSEA) have to anticipate and address potential problems before actually deploying the equipment.

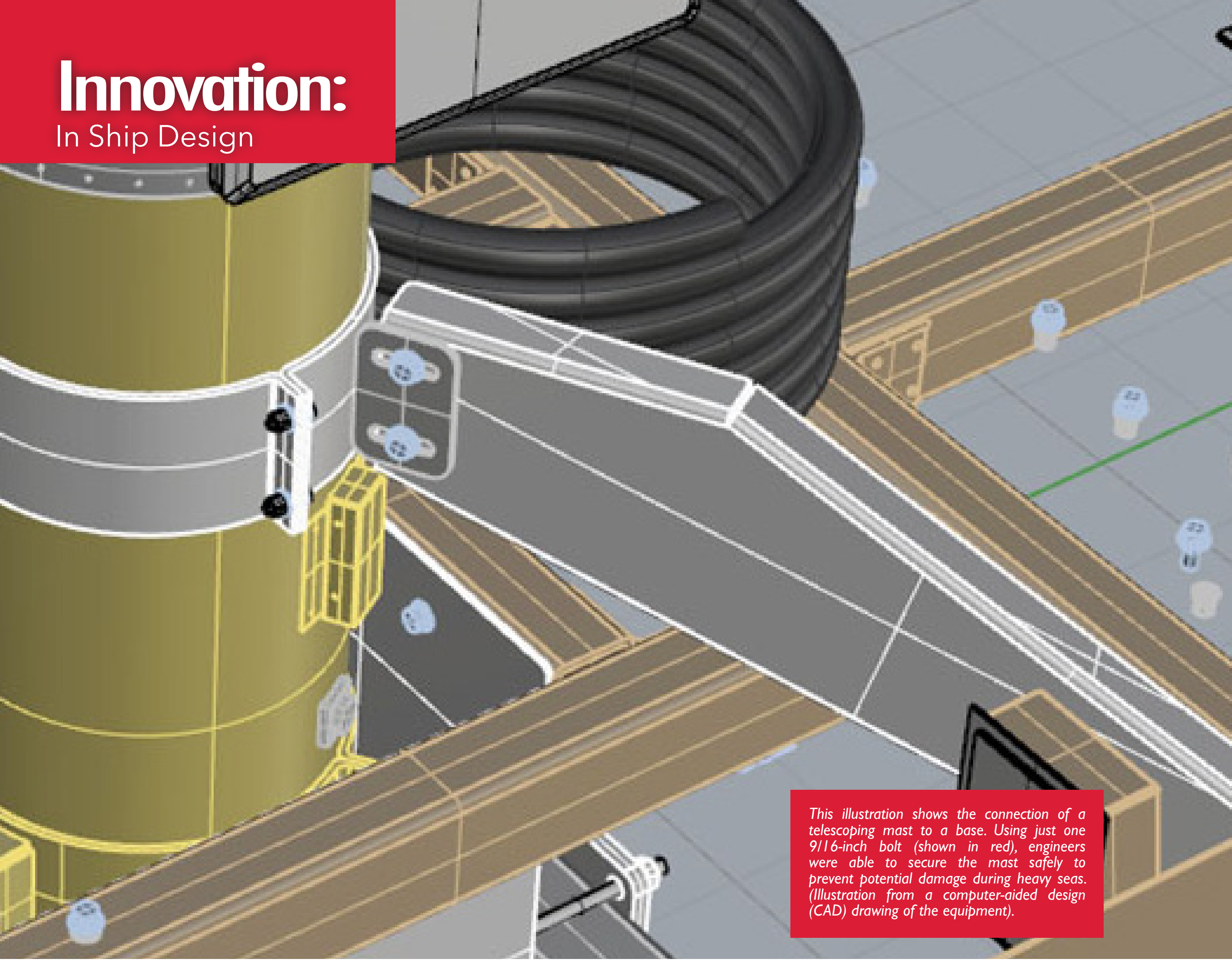
As NSWC Crane was preparing the sensor equipment to go aboard USS Arlington (LPD 24), a San Antonio-class amphibious transport dock, for at-sea testing, they knew they would need to find out the limiting operational sea state with the mast fully extended to operate safely during trials.

Carderock was able to make some quick calculations based on the technical specifications provided by the mast manufacturer and engineers at NSWC Crane.

For this particular problem-solving effort, not only did Warfare Centers collaborate with each other, but also technical codes within Carderock. Smith's branch, part of the Naval Architecture and Engineering Department, calculated the seaway accelerations, wind loading and vortex-shedding frequency for the equipment under operational conditions at sea. Then the problem was handed over to Carderock's Structural Composites Branch, part of the Platform Integrity Department, to determine if the material and the structure itself would hold up under those loads.

Paul Coffin, a materials engineer in the Structural Composites Branch, said all of this analysis was done at their desks with just the specifications and computer-aided design (CAD) drawings of the mast.

"In a sense it was easy, because we were not predicting when it would break, we were trying to predict when it would



This illustration shows the connection of a telescoping mast to a base. Using just one 9/16-inch bolt (shown in red), engineers were able to secure the mast safely to prevent potential damage during heavy seas. (Illustration from a computer-aided design (CAD) drawing of the equipment).

work," Coffin said. "So we didn't really need the exact properties of the carbon fiber, for example; we could just work with the standard."

Initially, Coffin said they determined that the mast was fine to operate through sea state 6, but then they got a more detailed CAD drawing and found that while the mast was fine, the place where the mast connected to the equipment trailer would not hold up under the predicted load. He said the slotted connection used didn't require perfectly machined parts in order to match the mast to the base, but it also meant there could be a problem under heavy sea states and winds, something they would need to address for this short-term test meant to determine the mast's capabilities under load.

Using friction coefficients that NASA specifies for friction joints, Coffin did some basic calculations and found that the joint would start to slip under lower loads than the potential loads they could see on the ship.

"That's not good. We asked them if they could just drill a hole and add a bolt and they said, 'Sure,'" Coffin said, adding that the bolt would help to make the connection more stable and wouldn't allow for slippage.

Engineers at NSWC Crane tested the system aboard the ship in June and found it to operate as expected with no problems under loads.

"This was outstanding collaboration," said Nathan Thomas, chief engineer for NSWC Crane Division's Command, Control, Communications, Computers, Combat, Intelligence, Surveillance and Reconnaissance Integration Division. "We were able to make minor modifications to our mast assembly to safely install the system aboard the ship based on the recommendations made by Carderock after their analysis."

Coffin said this all happened very quickly. NSWC Crane reached out to them in the spring and asked for the assessment and by mid-May, they were able to provide feedback.

"I guess, philosophically, one of the things we try to do here is to react very quickly to requests," Coffin said.

Hough presents overarching ship-design process at Rear Adm. David Taylor lecture

By Brooke Marquardt, Carderock Division Public Affairs

Armed with color-coded slides and the occasional joke, Jeff Hough gave a lecture on the overarching naval ship-design process in a July 12 presentation at Naval Surface Warfare Center, Carderock Division in West Bethesda, Maryland.

Hough, Carderock's distinguished engineer for ship design, was the speaker for the monthly Rear Adm. David W. Taylor Naval Architecture Lecture Series. He is also the organizer of the lectures.

He started the presentation by getting a read of the room, asking how many people worked on ship design, and emphasized the importance of understanding the extensive process.

"A Navy ship is a city confined in a large mobile structure continuously operating in a hostile environment, the sea," Hough said.

According to Hough, the fundamental process of designing a ship is essentially to design, analyze and decide concurrently on the total ship and all of the systems on and in the ship. He said there are 1,001 steps in designing a ship between initial concept development to delivery of a ship.

Ship design can be categorized into exploratory, engineering and production steps, each being different, but critical to the design and acquisition of a Navy ship. The time between initial concept design and delivery can be anywhere between eight and 15 years.

"Design is when you synthesize something, analyze it and then decide if you like it or not based on capabilities, feasibility and cost. For something simple, like a table, this is easy to do," Hough said. "But on a ship, you've got hundreds of people doing design of the ship and its systems, so it gets a little complex."

Ship design starts with the analysis of current and future missions of the Navy's fleet.

Innovation:
In Ship Design

The guided-missile destroyer USS William P. Lawrence (DDG 110) practices ship maneuvers as it transits the Pacific Ocean on June 23, 2018. William P. Lawrence is operating in the U.S. 3rd Fleet area of operations conducting qualifications and routine operations. (U.S. Navy photo by Mass Communication Specialist 2nd Class Jessica O. Blackwell/Released)

"If you remember nothing else, there are three types of design: exploratory, engineering and production," Hough said, adding that the ultimate metric of success is getting a ship built. "Until we deliver a finished ship to the Navy, we really haven't done our jobs."

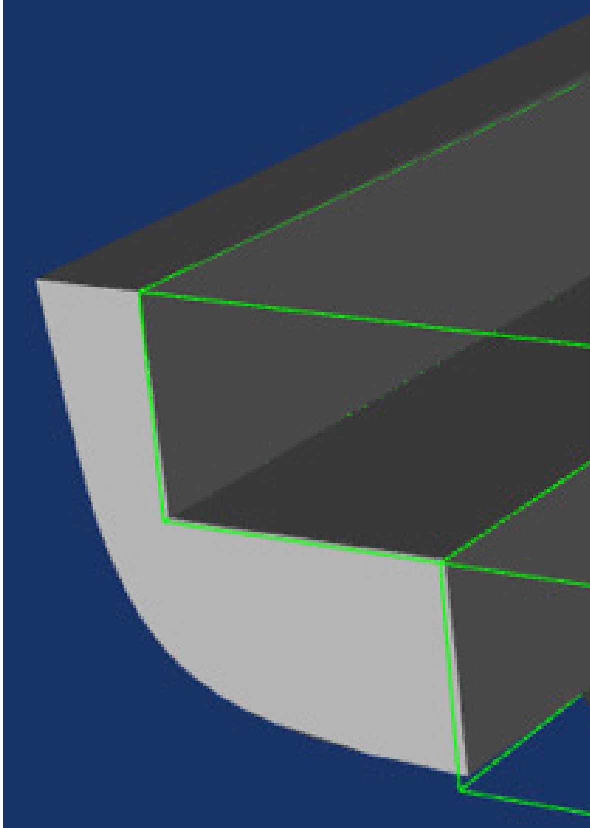
"At the conceptual or exploratory design phase, the designer has to correctly predict the entire sum of the parts of the ship before he knows all of the details. I need to know all the volume I need on that ship, because, for example, the underwater volume is in direct correlation to how much power I have to put in the ship to be able to push the ship through the water," Hough said. "Integration is key. Even if you have all of the items existing and tested, if they've never worked together on the ship, that's integration risk. Ships also have extremely high parts count and hours of labor — that's all part of the ship-building process."

Ships, labor and parts are continually getting more expensive, and according to Hough, the Navy has recently gone on record to say that they're extending the lives of their ships up to 50 years. Looking to future missions, ship design is slowly becoming improved by 3D modeling, and when done correctly, the model will show the whole ship — where every nut, bolt, panel and electrical wire is supposed to go. Advancements in technology and the workforce make it easier for ships to be maintained over their life cycles.

Hough ended the presentation by taking questions, and once again, emphasized that there are three ship design phases: the exploratory design, which is Navy led and performed; the engineering design, which is Navy led and Navy or shipbuilder performed; and the production design, which is shipbuilder led and performed.

Carderock NREIP intern beta tests design software

By Justin Hodge,
Carderock Division Public Affairs



Rachel Bielski, a rising junior at the University of Michigan studying naval architecture and marine engineering, spent her summer in the Naval Research Enterprise Internship Program (NREIP) beta testing a new data mapping and ship modeling tool at Naval Surface Warfare Center, Carderock Division.

Bielski worked with members of the Ship Design Tools Branch to analyze early-stage ship design requirements and translate them into technical requirements for the new concept-design software.

Before testing the software capabilities, Bielski was trained on the Advanced Ship and Submarine Evaluation Tool (ASSET) and the new Rapid Ship Design Environment (RSDE). Bielski, along with roughly 10 to 15 other interns, underwent a two-day training course building basic ship models to familiarize themselves with each design tool.

“ASSET was created to help naval architects move through the design spiral enabling them to create ships that met basic naval architecture requirements,” Bielski said. “This tool is more in line with traditional point-based design, but with the Navy’s move toward set-based design practices, the Ship Design Tools Branch needed to develop a program that would allow for design space exploration, which is why RSDE was created.”

In RSDE, users can set a range of values, variables or parameters of a specific ship, which creates a large design space, allowing for exploration of a variety of ship designs. This is helpful for projects where requirements are unknown, or where there may be trade-offs between different ship designs.

Bielski’s next task was to choose a design concept, which she would be working with for the remainder of the summer.

“After I was proficient enough to perform the necessary tasks within the system, I chose a destroyer model to use for the test,” Bielski said. “The model imported successfully into RSDE, and from a naval architecture perspective it is a mid-size craft, so you can get some really good test results.”

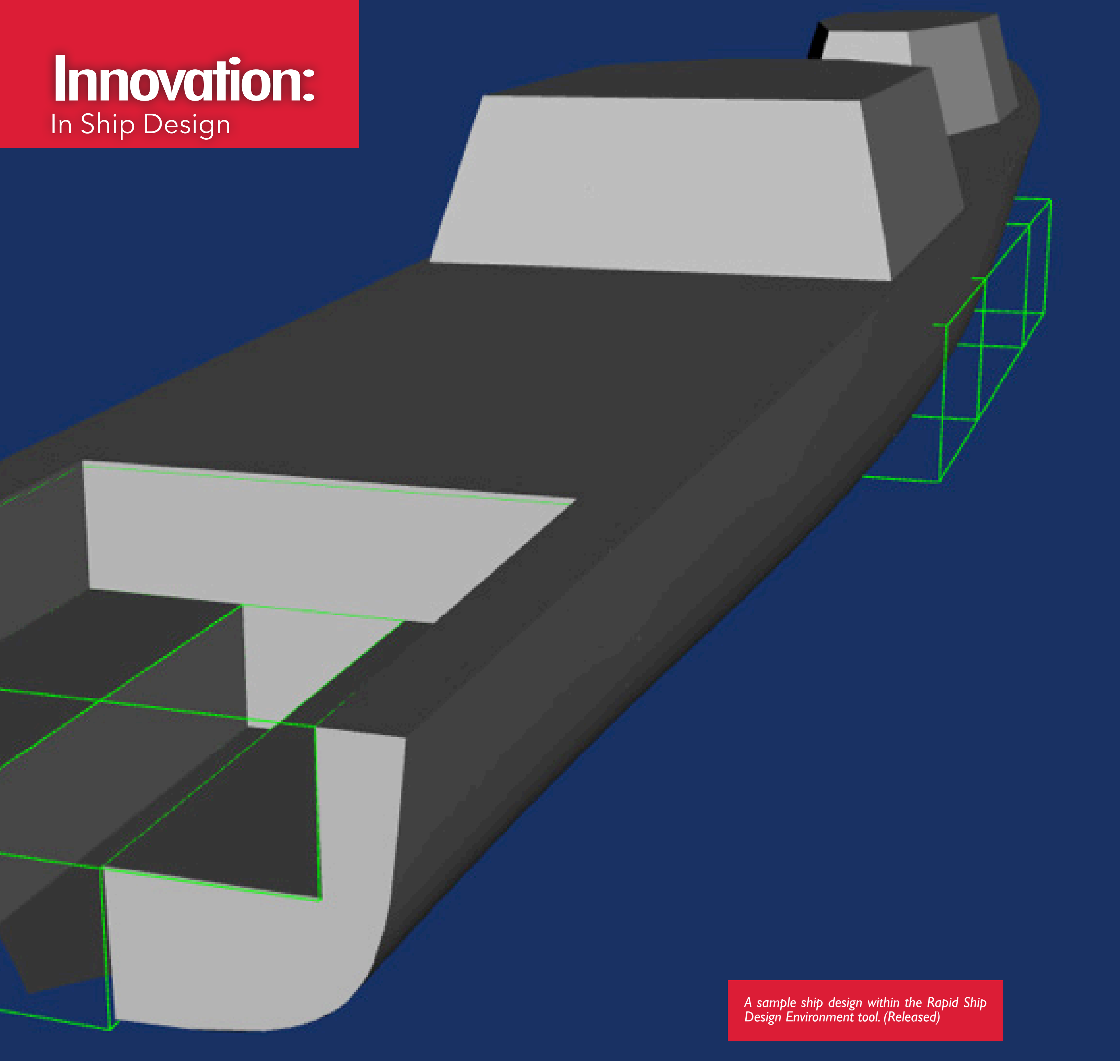
Bielski said that her next task was quite laborious, as she needed to upload information into RSDE from a design model stored in ASSET, and map the data sets so users had a point of reference to begin modeling in the new design tool. To do this, Bielski pulled data from ASSET and pasted the information into an Excel spreadsheet.

“The reason I moved the information into Excel was because the reports I pulled from ASSET were in PDF format, so I couldn’t manipulate the data,” Bielski said. “By using Excel I could add an equation to find the percent difference of each data set and any percentage point greater than 5 percent was highlighted.”

Bielski said the greatest variances her results produced were in ship-work breakdown structure weights and locations.

“For each of the categories — weights, longitudinal center of gravity of an object or payload, transverse center of gravity or vertical center of gravity — at least one of them had a difference of 5 percent or more,” Bielski said. “But the important thing to remember is that something about the theory or the equation could have changed, so it didn’t necessarily mean the program was broken. It means the next step was for me to go back and dive deeper into the data to understand why those differences occurred.”

Bielski also said that some of the information that wasn’t found at all was in hull geometry, hull structures and machinery reports. She did, however, say some of the information was accounted for, as it was marked with an asterisk in the reports, directing her to review the developers' release notes.



A sample ship design within the Rapid Ship Design Environment tool. (Released)

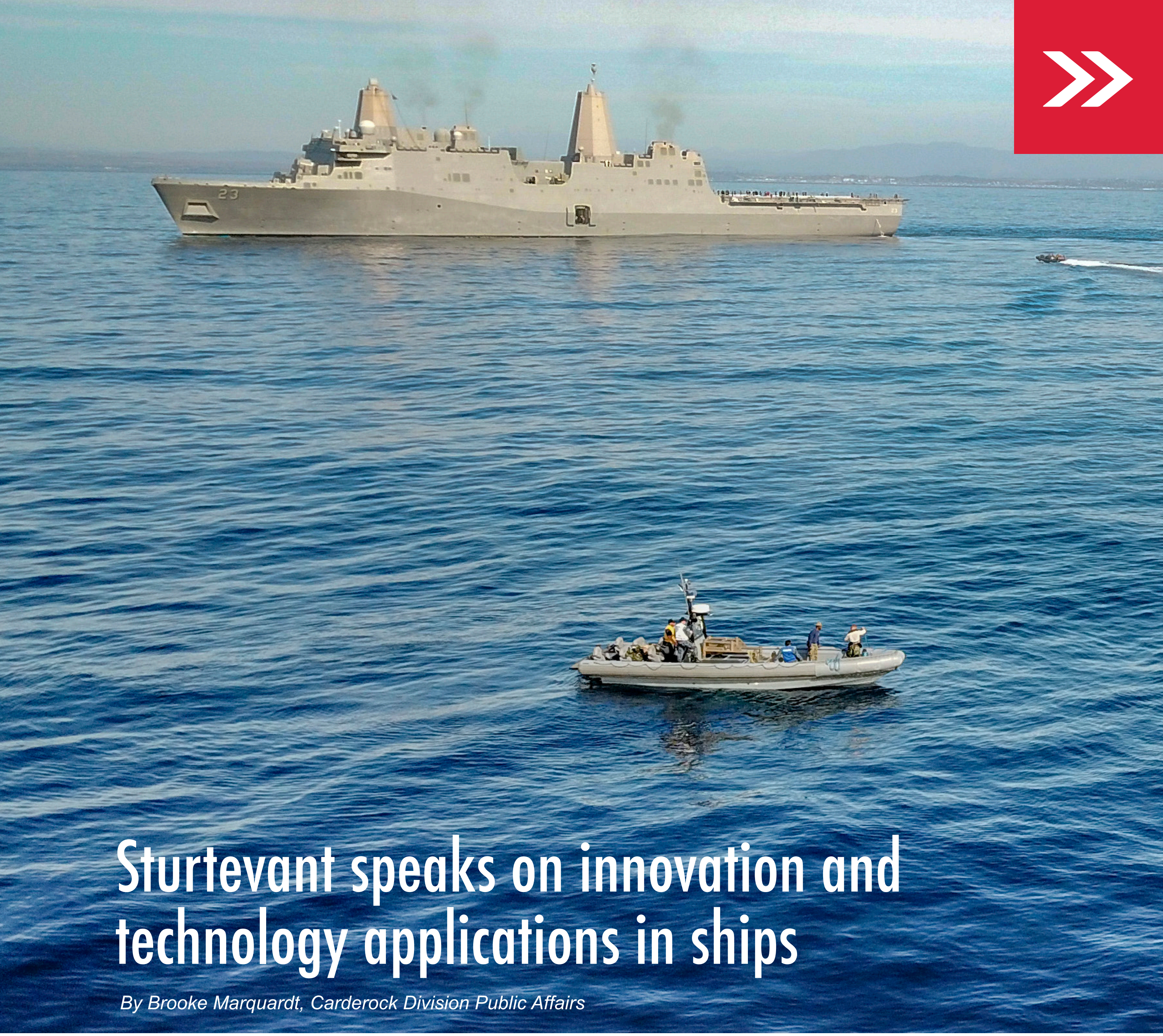
"In some instances where I couldn't find any information, I realized the developers had already swapped it out for 3D models," Bielski said.

Bielski said, overall the RSDE interface was easier to interact with, and complimented the development team for listening to user feedback and implementing those ideas.

Bielski said longtime users of the legacy system are more reluctant to switch to the new design tool, but she encourages the change as the upgraded interface allows users to easily manipulate designs through 3D modeling.

"When a user opens tool utilities in ASSET, they interact with tables, boxes and pop-up windows," Bielski said. "In RSDE users are interacting with 3D displays, so it's visually appealing and the new interface is more intuitive."

This was Bielski's first summer as an NREIP intern at Carderock, and she expressed gratitude for the experience she received working in a professional setting within the Ship Design Tools Branch. She also said she will benefit greatly from the work she did during her internship, as it helps guide design projects she may take on throughout her college curriculum.



Sturtevant speaks on innovation and technology applications in ships

By Brooke Marquardt, Carderock Division Public Affairs

Glen Sturtevant talked about applying innovative technologies in multiple areas on Navy ships during a presentation on Aug. 2 at Naval Surface Warfare Center, Carderock Division, in West Bethesda, Maryland.

Sturtevant is the director for science and technology for the Program Executive Office Ships (PEO Ships) and Naval Sea Systems Command (NAVSEA) 21, which manages the construction and sustainment of surface ships for the Navy.

Sturtevant's multi-faceted presentation focused on how the Navy is using advanced technology to improve ship capabilities. He highlighted several areas that are using advanced technology, such as: flight deck thermal management; polysiloxane topside coating; environment and ship-motion forecasting; fog-piercing imaging sensors; vertical launch system re-arming at sea; metamaterials; and collision-avoidance operator decision aid.

"Innovation is in the application. You're taking an existing technology or something that is emerging and applying it to a completely different application than what is was intended. And it has a lot of attraction because the cycle time is reduced," Sturtevant said.

While all of the things Sturtevant mentioned are important to the improvement of the Navy's ships and Sailor safety, he discussed in detail the technology improvements to ships in order to help with collision avoidance. Over the past few years there have been several ship collisions in the Navy, some resulting in the loss of life. Sturtevant said artificial intelligence-based unmanned surface vessel technology is being used to help reduce the rise of ship collisions. He said Sailors have said it is like "Alexa at sea."

According to Sturtevant, the Navy is currently leveraging Defense Advanced

Navy divers and crew members assigned to the San Antonio-class amphibious transport dock ship USS Anchorage (LPD 23) work to recover a mock-up capsule designed to simulate the size, shape, mass and center of gravity of the Orion crew module that will splash down in the Pacific Ocean following Exploration Mission-1 planned for December 2019. Anchorage was underway to support NASA's Underway Recovery Test 6 on Jan. 22, 2018. (U.S. Navy photo by Chief Mass Communication Specialist Paul Seeber/Released)

Research Projects Agency (DARPA) and the Office of Naval Research's (ONR) investments in this new technology and is taking advantage of artificial intelligence and rapid data analytics. This, in turn, will provide improved safety of navigation, seamanship and ship-handling performance of the integrated watch-standing team on the bridge and in the combat information center.

He said the Navy is adopting improvements to its ship-motion technology to understand the dynamic ocean environment, as well. This new technology is used to predict weather, waves and swells. It has already been implemented on Navy ships like USS Anchorage (LPD 23) to recover a mock-up capsule designed to simulate the size, shape, mass and center of gravity of the Orion crew module that will splash down in the Pacific Ocean following Exploration Mission-1 planned for December 2019.

Another technology Sturtevant discussed was the "electro-optical imaging sensors to see through obscurants" project, used on ships to see through fog, haze, rain and snow. By adding to this technology, it could be possible to also see through sandstorms, smoke, dust and other obscurants. He said this was the perfect example of innovation being in the application, and it is just one of many successful examples.

Sturtevant graduated from the College du Leman in Geneva, Switzerland, and earned a Bachelor of Science in civil engineering from the University of Delaware. He earned a master's degree in management from Indiana University, and he completed program management and engineering programs of study at National Defense University, Webb Institute, Virginia Tech and Massachusetts Institute of Technology.

Sturtevant began his career with the Navy in 1978 as a project engineer and has taken positions with increasing responsibilities; he has been assigned to his current position since 2007.

Weaponry, technology and threats improve destroyers over time

By Kelley Stirling, Carderock Division Public Affairs

With the advancement of technology and weaponry, as well as evolving threats to the United States, the progression of the U.S. Navy destroyer has changed dramatically over the years.

The first destroyers, built more than 100 years ago, were designed as torpedo-boat destroyers, said James Harrison, director for the Expeditionary Warfare Ships Division at Naval Sea Systems Command, during another one of his "history lessons" at Naval Surface Warfare Center, Carderock Division in West Bethesda, Maryland, on Sept. 6.

In "From Flivvers to Flight III," Harrison talked about the evolution of the Navy's destroyers. He called the very first destroyers built starting in 1899 "proto-destroyers" since the Navy was still trying to figure out exactly what a destroyer should be. He said he considers the "flivver," commissioned in 1909, the first ship built with a true destroyer mission.

While other navies were building torpedo boats to go after battleships, which were large and expensive, the U.S. Navy decided to build less-expensive, ocean-going, high-speed boats to protect the battleship and other high-value assets from asymmetric threats.

"You don't want your battleships fighting torpedo boats, you want them fighting other battleships," Harrison said.

The Smith- and Paulding-class torpedo-boat destroyers, starting with USS Smith (DD 17), became known as flivvers, because the ship was built in fairly high numbers, was high-powered and shook and rattled when it was underway, similar to the Model T Ford at the time, which had the nickname "flivver."

Throughout the history of designing and building destroyers, the Navy considered threats in the world at the time, whether it was torpedo boats, as in the case of the flivver, or fast-attack crafts for the Arleigh Burkes.

"Before they even delivered the first of the flivvers, the Navy was taking another round turn on the design," Harrison said.

By the time the U.S. entered World War I, the Navy had three types of destroyers: the proto-destroyers, flivvers and what became known as 1,000-tonners, of which USS Cassin (DD 44) was the first built.

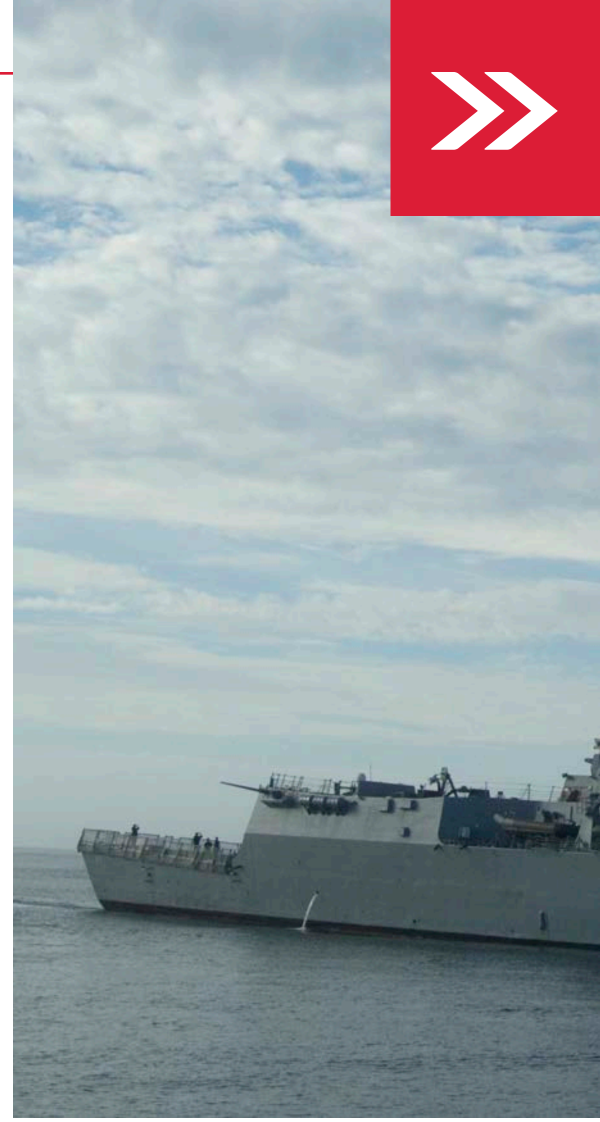
The 1,000-tonners did get more guns and torpedo tubes, adding to a destroyer's offensive capabilities, with the threat still being torpedo boats and enemy destroyers.

"When the ships were built, submarines were not a concern," Harrison said. "But, during World War I, the Germans are doing U-boat warfare. In fact, that's one of the reasons we are in the war."

The Navy added Y guns to project depth charges off either side of the ship with the objective of sinking a submarine. Harrison said it wasn't very effective, as only about 1 percent of depth-charge attacks resulted in the sinking of a submarine, but it was effective at preventing the submarine from launching an attack in the first place.

With anti-submarine warfare in mind, the Navy started building another class of destroyer before the end of World War I, called the flush deckers. With the larger ship, the Navy streamlined the forecastle, thinking it would be able to handle the waves better, which is why it is called a flush decker.

Harrison said that didn't seem to make a difference, no matter how large the ships became over the generations, so the Navy



ultimately went back to the larger, flared forecastle, which is still the case in the Arleigh Burkes.

The flush deckers, which became known as the World War I-era destroyers since they continued service into World War II, were built in very large numbers. Between April 2017 and the end of World War I, the Navy delivered 42 flush deckers, and after the war, most of the earlier destroyers were retired. In all, the Navy built 273 flush deckers. Many of these ships got mothballed, since the need wasn't there anymore.

The next line of destroyers the Navy started building in the 1930s became known as the gold platers, because of how much nicer they were than the flush deckers.

Sonar was added to the ships at this time, increasing the anti-submarine warfare capabilities, but not by much. Harrison said the early sonar meant pointing the hydrophone specifically in the direction a submarine was thought to be, listening, potentially hearing it and maybe tracking it.

Sailors aboard the guided-missile destroyer USS Preble (DDG 88) conduct an operational tomahawk missile launch while underway in a training area off the coast of California on Sept. 29, 2010.The launch tested the proficiency of the crew, as well as the missile's ability to track and destroy targets well over the horizon. (U.S. Navy photo by Mass Communication Specialist 1st Class Woody Paschall/Released)

Improvements in machinery engineering allowed the designers to start trunking from the boilers, therefore needing only one or two exhaust stacks, instead of the four that all previous destroyers had.

As air warfare became a threat, the Navy started adding anti-aircraft weaponry to the destroyer. With some of the gold platers, they replaced one 5-inch gun with 40-mm and 20-mm guns in service. They started adding shields to the guns, as well as more depth charges.

"Of the eight Farragut-class destroyers, one was sunk in battle and two were sunk by typhoon, because once all these modifications were made, they had very limited stability," Harrison said.

When the Navy built the next round of destroyers starting in 1942 at 50 percent larger, future improvements in technology were a consideration, leaving room for upgrades in anti-aircraft weaponry, especially during World War II, when the threat was Japanese aircraft. But by 1947, new threats in jets and the German Type XXI submarine made the Fletcher-class destroyer obsolete. After building 100s of the Fletcher class, the Navy began a fleet rehabilitation and modernization (FRAM) update to the ships in the 1950s, changing much of its weaponry to meet the challenges of the time.

Many of the upgrades included air conditioning and noise reduction technology, which meant the machinery would take up more space. The new destroyers also had more advanced radar and larger sonar. The guns became automatic and higher-velocity, shooting potentially 40 rounds per minute, versus 15.

With the Spruance-class destroyers, built in the 1970s, the Navy had gone to gas-turbine engines, finally shedding its decades-long dependence on steam, somewhat behind the rest of the world. The ship had more silencing technology and habitability improvements. The Spruance was also the first class of destroyers built with a modular weaponry system, allowing for somewhat plug-and-play upgrades.

Harrison ended his talk by focusing on the Arleigh Burke-class destroyer, a ship that some of the current naval architects at Carderock have worked on in their careers. The advancement in technology and weaponry was so vast in the Arleigh Burke, Harrison said, the Navy just kept making improvements to the same hull, calling the newer versions Flight I, Flight II and lastly, Flight III.

"In 100 years or so, we've gone from six guys standing on the bow, hoping they don't trip over something and fall over the side, looking down the barrel of a gun, trying to hit something maybe 300 feet away, to a ship that can knock down a ballistic missile hundreds of yards away in any weather, any condition," Harrison said. "What's next?"

CREATE Ships is a fundamental change in design

By Kelley Stirling, Carderock Division Public Affairs

The Rear Adm. David Taylor Naval Architecture Lecture Series took a turn to the present with the subject for the Oct. 11 lecture about current engineering software being used for ship design.

These lectures, held at Naval Surface Warfare Center, Carderock Division, have mostly focused on the history of certain aspects of ship design, starting with Carderock Commanding Officer Capt. Mark Vandroff's talk in February on the design and acquisition of the Arleigh Burke-class guided-missile destroyer (DDG 51) program based on his experience as the DDG 51 program manager. The October lecture focused on the Computational Research and Engineering Acquisition Tools and Environments (CREATE) Ships program, sponsored by Department of Defense's High-Performance Computing Modernization Program Office. The CREATE program was designed to improve the DOD acquisition process with the development of software tools to help generate and process design options, initially for ship design, and more recently for ship and submarine design in the case of Carderock.

According to Jeff Hough, Carderock's distinguished engineer for ship design and the organizer of the Taylor lectures, CREATE Ships was developed to potentially reduce and focus the amount of physical testing necessary during the design and construction of a new ship. In talking about the larger CREATE program, he said it was initially created by a nuclear weapons designer, Dr. Doug Post.

"They can't physically test nuclear weapons anymore," Hough said. "They have to use full physics-based modeling and simulation."

Hough said Carderock has been using advanced modeling techniques for decades, mostly in the science and technology realm to help understand phenomena. Recently, though, engineers are using it more for engineering with the idea that it may impact the acquisition process by reducing risk with the use of more physics-based tools.

"Instead of conceptually design, physically test, make a change and so on, we can do that with a lot of virtual testing," Hough said, adding that this could go a long way to helping achieve the chief of naval operations' goal of designing ships in half the time. "Maybe we don't want to cut the design time, but what you want is, 'I need a new ship, and I need it delivered to the Navy in half the time."

The three speakers, all from Carderock, were Dr. Alex Gray, a naval architect in the Ship Design Tool Branch; Jonathan Stergiou, modeling and simulation program manager in the Survivability and Weapons Effects Division; and Wesley Wilson, a mechanical engineer in the Computational Design, Analysis and Development Branch.

Each talked about the aspects of CREATE Ships they lead. Gray leads the team that is developing the Rapid Ship Design Environment (RSDE). The problem statement that ultimately led to RSDE was first seen in a Naval Sea Systems Command (NAVSEA) memo by Vice Adm. Paul Sullivan in 2008, which basically said the Navy needed the capability to generate and analyze hundreds of ship concepts in a short amount of time.

"That's specifically why the Rapid Ship Design Environment was developed and that is what the tool does to this day," Gray said. "It's a design-space exploration tool and we are using that data here at Carderock to support a set-based design approach."

Gray said RSDE can generate hundreds to thousands of concepts during design studies, generating information with physics-based design and analysis tools.

"We are generating the data, not because it's cool to have lots of data, but because we want to use that data to reduce our uncertainty and help make better design decisions," Gray said.

In their current efforts, Gray said RSDE allows them to study a problem and do parallel workflow under uncertain requirements. He used technology insertion, like a new weapon, as an example. He said if he were given a requirement to look at putting a new weapon that won't actually be developed for 10 years onto a ship, he would normally need to know specifics like the space, weight, area, power and cooling needs that best describe the weapon. With RSDE and with very limited basic information, he can run a design-space exploration, generate concepts, a large design space, and as long as those solutions are still within the constraints at the time of development, he can provide a design.

Gray said they hope to take RSDE to the submarine side in the near future. He said they are also doing some work with code optimization and user interfaces to make sure RSDE stays "rapid."

Stergiou talked about Navy Enhanced Sierra Mechanics (NESM), the CREATE Ships physics-based modeling and simulation suite for prediction of ship shock response and damage due to weapon engagement.

"Survivability plays a critical role in ship designs and considerations, and historically, it has not been heavily considered until later stages of design," Stergiou said. "And one of the things we would like to try to do is get that in earlier."

Innovation:
In Ship Design

Jonathan Stergiou, modeling and simulation program manager in the Survivability and Weapons Effects Division, talks about Navy Enhanced Sierra Mechanics software that's part of the Computational Research and Engineering Acquisition Tools and Environments (CREATE) Ships Project, during the Rear Adm. David Taylor Naval Architecture Lecture at Naval Surface Warfare Center, Carderock Division on Oct. 11, 2018, in West Bethesda, Md. (U.S. Navy photo by Kelley Stirling/Released)

Stergiou said that when they do a shock trial on a new class of ship, they don't know the exact environment of the ship until they go through an entire full-ship shock trial (FSST). At that point, the ship is already built, and the second and third ship in the class are likely being built, so it's too late to significantly change any designs.

"One of the ideas here is to understand that as early as we can, and fundamentally change how we do those design and assessments and do a better job of isolating the machinery and improving the survivability and recoverability of our ships," Stergiou said.

He said the desired end state was a process that includes enhanced testing supported by dynamic simulation, using high-fidelity modeling, of the response and performance of the ship in an underwater explosion environment that can be used in place of the role traditionally filled by the FSST. He also said none of that matters if people can't make better decisions to design better ships.

"We are working very closely with our tech authority, with our community and our customers, making sure that the capabilities we provide are what they are looking for, and that we are targeting their problems correctly," Stergiou said. "The bottom line here is we need to be good stewards of the taxpayers' money, so that we can design better ships or do more assessments of the same ships to understand them more comprehensively."

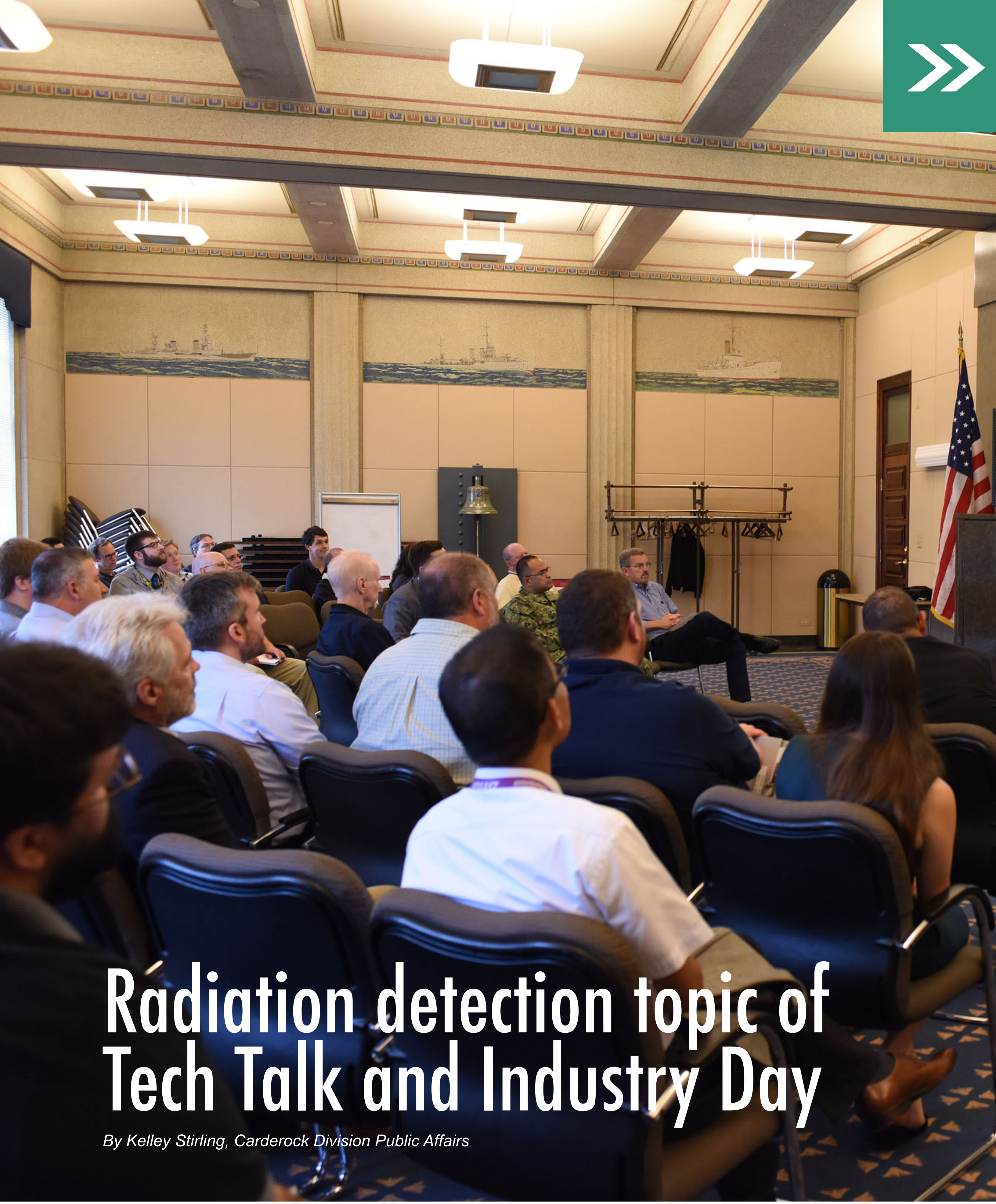
Wilson talked about the CREATE Ships tool for ship hydrodynamics, called NAVYFOAM, which offers accurate, detailed calculations to accelerate and improve all stages of ship hydrodynamic design, and the Integrated Hydrodynamics Design Environment (IHDE), an integrated software environment for naval architects and hydrodynamicists that integrates a suite of hull-form analysis tools, including visualization.

Wilson said there was an opportunity for collaboration between the ships and air vehicle communities to incorporate a well-established compressible, dual mesh code, called Kestrel, into IHDE with the objective being to add an incompressible solution algorithm for application to Navy problems. This effort provides a means for high-quality automated, volume-grid generation and high-fidelity hydrodynamics solutions within the existing ship design context.

"We've kind of hitched our wagons to this technology a little bit," Wilson said. "What it does is it allows us to leverage resources across agencies, between Air Force, Army and Navy. In particular, this helps to accelerate software development by taking advantage of the existing software architecture."

According to Stergiou, all of the CREATE Ships efforts have a 10-plus year roadmap, giving them direction whereby they can make sure whatever technologies they are inserting and pursuing align with NAVSEA's shipbuilding acquisition plans.

"One of the amazing things about CREATE is it's been here for 10 years and it doesn't look like it's going anywhere any time soon," Stergiou said. "Physics-based engineering tools are the future."



Radiation detection topic of Tech Talk and Industry Day

By Kelley Stirling, Carderock Division Public Affairs

Innovation
at work

Dr. Kanai Shah, president of Radiation Monitoring Devices, Inc., speaks during a Tech Talk on June 4, 2018, at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md. Carderock's Radiation Technology and Systems Safety Branch held the Tech Talk on the subject of new improvements to scintillator crystals, a type of radiation detection. (U.S. Navy photo by Kelley Stirling/Released)

Radiation detection manufacturers showcase advancements in radiation detection technology at an Industry Day held by Naval Surface Warfare Center, Carderock Division's Radiation Technology and Systems Safety Branch on June 5, 2018, in West Bethesda, Md. (U.S. Navy photo by Kelley Stirling/Released)

The Radiation Technology and Systems Safety Branch of Naval Surface Warfare Center, Carderock Division held a Tech Talk on June 4 and an Industry Day on June 5, both on the subject of radiation detection technology.

Dr. Kanai Shah, president of Radiation Monitoring Devices, Inc., was the guest speaker for the Tech Talk and his presentation was about new improvements to scintillator crystals, a type of radiation detection.

Radiation detection manufacturers from 26 vendors participated in the Industry Day, showcasing the latest advances in radiation detection technology.

"This Industry Day offers a unique environment solely focused on instrumentation and dosimetry," said Meredith Wood, a nuclear engineer with the Radiation Technology and Systems Safety Branch.

Wood said this was the fifth year her branch has held the Industry Day and Tech Talk and each year it is more successful, giving participants the opportunity to discuss radiation detection needs with each other.

Jeff Hough, Carderock's distinguished engineer for ship design, leads a discussion on model-based systems engineering and set-based design during a Naval Research and Development Establishment collaboration forum on Aug. 1, 2018, at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md. (U.S. Navy photo by Kelley Stirling/Released)

Collaboration forum brings researchers from Navy labs to Carderock

By Kelley Stirling, Carderock Division Public Affairs

The Naval Research and Development Establishment (NR&DE) held a Collaboration Forum July 31 to Aug. 1 at Naval Surface Warfare Center, Carderock Division in West Bethesda, Maryland. The event included science and technology (S&T) representatives from Naval Sea Systems Command (NAVSEA), the Office of Naval Research (ONR), the Naval Research Lab (NRL) and the Navy's Warfare Centers.

Organized through a dialogue between Chief of Naval Research Rear Adm. David Hahn and NAVSEA Warfare Center Executive Director Don McCormack, the purpose of the collaboration forum was to discuss and share research happening across the Navy, specifically within the NAVSEA realm.

"We are involved in the full lifecycle, and I think that's unique for any of the Navy's activities," McCormack said, speaking of the Warfare Centers' reach across the Navy. "We go from S&T all the way through in-service, and ultimately, disposal of those parts. We have a pretty good understanding of the lifecycle of the products you're trying to get out. You understand how the warfighter uses them, and you have all that performance and reliability data. You have all of that information in the Warfare Centers."

Presenters from ONR, NRL and the Warfare Centers talked about the areas they are investing money, specifically briefing projects that fall under the Naval Innovative Science and Engineering (NISE), Section 219 funding, the idea being to communicate across the NR&DE where they are focusing their efforts and to see if there are opportunities to work together. Other investment resources, like in-house laboratory independent research, were also discussed during the forum.

"We've been thinking about the portfolio and how we align our efforts across the board," Hahn said, adding that in looking at the challenges going forward, he and McCormack decided the collaboration forum was necessary. "I've been on this windmill push and effort to try to knock down those things that either structurally prevent us from working together, or behaviorally prevent us from working together, to include the fact that we each come from different organizations. I want to make sure that we understand how we, together, are moving forward and where we've been so that we can continue to move forward."

Breakout-session topic areas during the two-day event included unmanned systems and autonomy; quantum sciences; decision science; distributed research and collaboration; artificial intelligence and machine learning; model-based systems engineering and set-based design; digital science and strategy; virtualization and live-virtual constructive; and hypersonics.

In the unmanned systems and autonomy forum, Lee Mastroianni talked about what interests him as a program officer within ONR's Expeditionary Warfare and Combating Terrorism Program.

"Platforms that can operate multi-domain," Mastroianni said. "What do we want these platforms to do in the autonomy and the C4 (command, control, communications and computers) that enables that? It's the brains behind the operation. That's where, from my perspective, I want to put the investments and the areas I think we can collaborate on."

Another area Mastroianni said he was interested in is the test facilities for unmanned and autonomous systems. These types of tests are very complex and are made even more difficult by range restrictions and policies.

Dr. Tom Devine, a naval architect in Carderock's Advanced Capabilities Branch, agreed and suggested that the Warfare Centers have test facilities that might be useful to other Navy labs and programs.

"Each of these Warfare Centers and each of these activities have unique test ranges that don't exist anywhere else in the world," Devine said. "And it would be a mistake not to take advantage of those test ranges."

Chief of Naval Research Rear Adm. David Hahn speaks to representatives of the Naval Research and Development Establishment at a collaboration forum on July 31, 2018, at Naval Surface Warfare Center, Carderock Division in West Bethesda, Md. (U.S. Navy photo by Kelley Stirling/Released)

In the breakout session for model-based systems engineering and set-based design, Mike Traweek, a program officer in ONR's Ocean Battlespace Sensing Program, said he thinks the collaboration forum was motivated by the idea that ONR program officers should be more closely connected to the laboratory or the Warfare Centers. He said the advantage of being there was that he can communicate directly to the researcher about what he's investing in and why.

"Along the way, by necessity, I've invested in the development of methodologies intended to efficiently connect and communicate the lowest-level observable and controllable parameters that describe system components to high-level mission objectives that we seek to obtain in the actual employment of the systems," Traweek said, meaning that he wants set-based design and systems engineering programs to succeed because it is essential to have the warfighter involved and the mission in mind from the beginning of the design process.

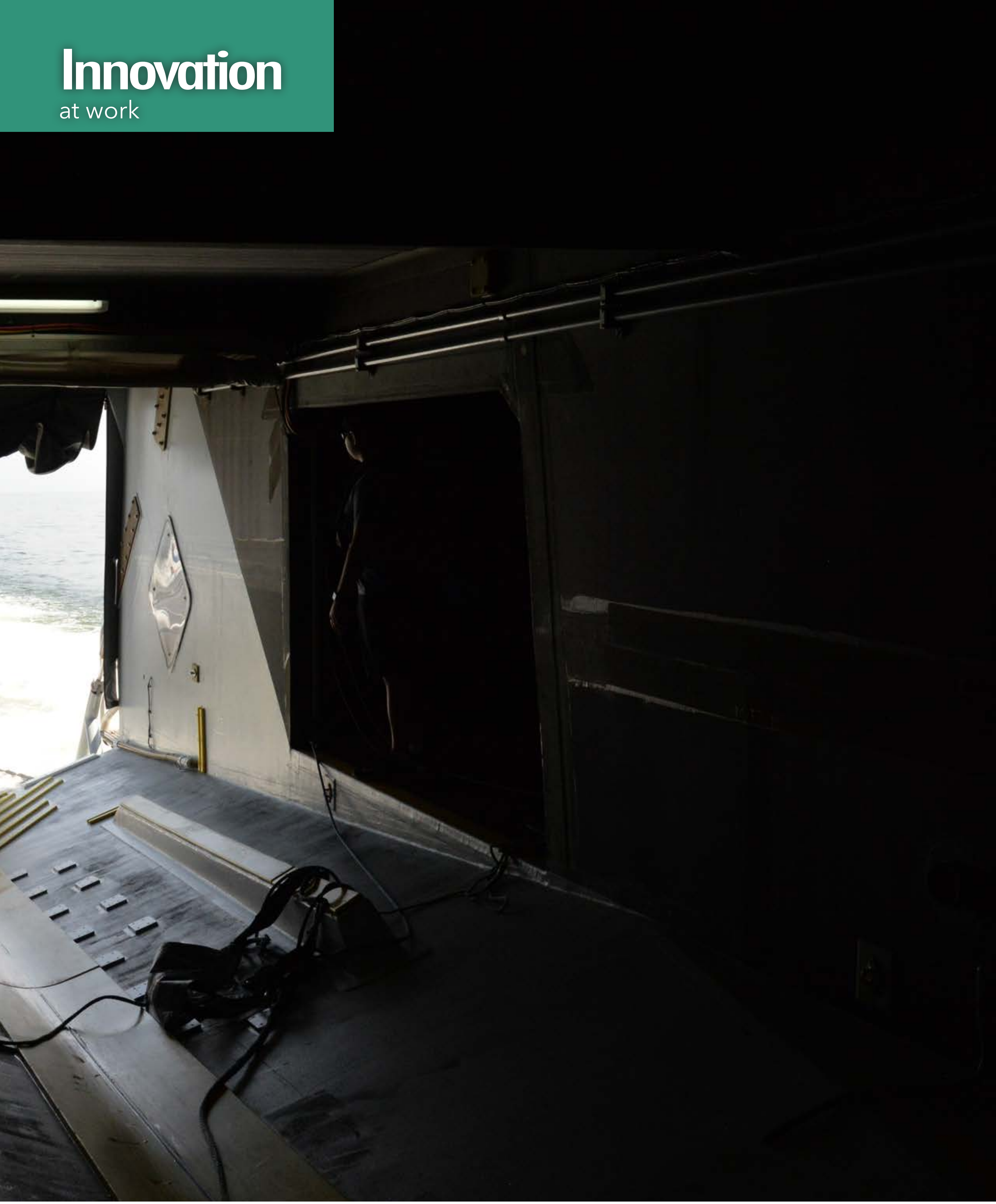
When Hahn spoke at the beginning of the program, he reminded people what the ultimate objective is.

"At the end of the day, we are in a great power competition. And the other guys are also in a great power competition," Hahn said. "The objective is not to be in a competition; it's to win the competition. For us to do our part of this, we have to rethink our activities, our behaviors, inside of our resource alignments and our resource allocations, so we get our people working together on important stuff."

The collaboration forum is intended to be the first of a series of recurring NR&DE events, likely expanding to include other Systems Commands, including Naval Air Systems Command (NAVAIR) and Space and Naval Warfare Systems Command (SPAWAR).

Stiletto launches RIB

Boat Capt. Tim Boger signals that he is clear and ready to start engines as the 11-meter rigid inflatable boat (RIB) launched from Stiletto during a maritime demonstration of radar systems Aug. 17, 2018, off the coast of Joint Expeditionary Base Little Creek-Fort Story, Va. Stiletto is the maritime platform used for technology demonstration; it is operated by Naval Surface Warfare Center, Carderock Division's Combatant Craft Division in Norfolk. The Stiletto Maritime Demonstration Program is sponsored by the Rapid Reaction Technology Office under the assistant secretary of defense for research and engineering. (U.S. Navy photo by Kelley Stirling/Released).



Coordinated efforts for digital twin underway

By Justin Hodge, Carderock Division Public Affairs

Innovation
at work

Dr. Dave Drazen, digital twin program manager at Naval Surface Warfare Center, Carderock Division, speaks about the future of the Navy's digital twin platforms initiative, during a brown bag on Aug. 16, 2018, at Carderock's headquarters in West Bethesda, Md. (U.S. Navy photo by Neubar Kamalian/Released

Dr. Dave Drazen, digital twin program manager at Naval Surface Warfare Center, Carderock Division, best described Navy digital twin as a virtual representation of a physical system that utilizes data and physical models to provide deeper insight into platform capabilities during a brown bag at Carderock's headquarters in West Bethesda, Maryland, on Aug. 16.

"Navy digital twin is a blend of data, physics-based models and machine learning combined with our best knowledge of the ocean battlespace to forecast platform performance," Drazen said. "These insights will help to improve situational awareness across the fleet and enables a user to readily identify optimum, actionable decisions."

The U.S. Navy is working to create a digital twin framework that enhances the capabilities at the individual vessel and fleet levels through an improved understanding of platform-specific condition. This framework will enable users to probabilistically assess, predict and manage ship performance based on the relevant operating environment.

"We want to augment human decision making by providing relevant information while integrating near-term and long-term logistics and mission requirements," Drazen said.

Carderock Division's efforts are aligned with the objectives of the Digital Warfare Office (DWO) to expand data-driven decision making, improve the ability to share information to support outcome-oriented data strategies, grow a culture that promotes digital talent and evolve Navy processes to promote data and software-rich capabilities.

"There are several fleet needs that currently drive the focus of our initial digital twin development efforts," Drazen said. "These needs are increased situational awareness of platform signatures, unmanned vehicle needs for real-time condition assessment, increasing the operational availability of the fleet and extending ship service life."

In terms of Navy digital twin platforms, Carderock Division is taking the lead for Naval Sea Systems Command (NAVSEA) while working with Naval Research and Development Establishment (NR&DE) partners to deliver an integrated capability.

Drazen said Carderock is responsible for surface, subsurface and unmanned vehicles (UxV) platforms, the development of enabling technologies and infrastructure, the integration of efforts into comprehensive platform representations and transition of these capabilities into products that solve current problems the fleet is facing.

During the presentation, Drazen said the existing Department of the Navy information technology infrastructure does not provide the framework needed to develop the digital Navy and digital twin.

"At this time, we don't have the necessary tools to develop this technology, therefore a cross-NR&DE Digital Twin collaboration workshop was held at Carderock Division in February 2018 and a working group was formed so we can coordinate our efforts and advocate for needs across the enterprise," Drazen said.

The working group is working on developing a cloud-based framework to implement developmental digital twin models.

Moving forward, the Navy will continue working to develop common tools that apply to submarines and ships — both manned and unmanned — to develop roadmaps to coordinate these efforts and determine the expected rate of technology maturation. Carderock will look to leverage Naval Innovative Science and Engineering (NISE) 219 funding to inform and complement Office of Naval Research science and technology investments, partnering with NR&DE to identify appropriate work and determine how to best provide increased warfighting performance to the fleet.

Carderock hosts advanced power and energy meeting

By Brooke Marquardt, Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division hosted a quarterly advanced power and energy strategic senior leadership meeting Sept. 6-7, 2018. The leadership in attendance from the Navy's Warfare Center Divisions in Carderock, Crane, Philadelphia and Newport oversees nearly all of the Navy's expertise in power and energy storage. These divisions are the most engaged in the research, development, testing, fielding, integration and subsequent in-service engineering of these systems.

Although each of the divisions plays a role in these fields, a single Warfare Center cannot do it alone, according to Jim Higgins, head of Carderock's Environmental and Energy Division. It is the combined efforts of these engineers and scientists that provide the Navy and their warfighters the information and technology that they need in order to be successful.

Higgins said that for the next 10 to 30 years, lithium batteries will play a critical role in enabling autonomous systems, shipboard power, undersea dominance and aviation. Fuel cells may break through and find their own applications, but batteries will remain the dominating technology.

According to this group of power and energy experts, in order to succeed in this area, it is critical that the collaborative Warfare Centers:

- Have a capable, well-trained workforce.
- Have the facilities and equipment necessary to meet future tests and development needs.
- Are collaborating and communicating effectively with the community.
- Provide unified support of USMC, NAVSEA 05Z34, the ship design managers, the PEO program managers and other major sponsors.
- Have a unified message on commonality, such as the safe, common, affordable power and energy storage (SCAPES) concept, and are actively and continuously working with program managers to standardize cells, modules, systems, battery monitoring systems (BMSs), and physical and software interfaces.

Rob Skelding (far right), an engineer in Naval Surface Warfare Center, Carderock Division's Advanced Power and Energy Branch, describes the hybrid-power test station to members of the Advanced Power and Energy strategic senior leadership group on Sept. 6, 2018, during a tour of Carderock facilities. (U.S. Navy photo by Kelley Stirling/Released)

"These four Warfare Center divisions have collaborated on power and energy issues for the Navy and Marine Corps for many years, so the community knows one another well. But the rapid escalation in development and application of lithium-ion batteries and other advanced power solutions across the military made it clear that we needed to share knowledge and expertise and strategize collectively on a more regular basis," Higgins said. "This drove the establishment of the quarterly power and energy leadership coordination meetings."

In addition to a tour for the visitors of the tow tank, battery test facility, hybrid test facility, the MAKE Lab, the MASK and the Explosive Test Pond, major topics of discussion were:

- Advanced power and energy current projects
- Carderock Disruptive Technologies Lab
- Unmanned systems Community of Interest
- High voltage safety training, challenges and practices

Jim Higgins contributed to this article.

Carderock shares resources with MIT

By Brooke Marquardt,
Carderock Division Public Affairs

Recently, Naval Surface Warfare Center, Carderock Division has partnered with the Massachusetts Technical Institute (MIT) in their Industrial Liaison Program (ILP) offering many research, collaborative and learning opportunities for all Carderock Division employees.

Hong Fan, program director of corporate relations at MIT, visited Carderock Division in West Bethesda, Maryland, on Sept. 20 and elaborated on the many opportunities and resources available via the program to all those that sign up.

MIT has a long history of collaboration with the Department of Defense, and they are dedicated to enhancing and building on already existing relationships through their ILP. Currently, two of their largest projects are 3D printing technologies and the Defense Fabric Discovery Center, where they're working to combine technology into military uniforms.

The MIT ILP is dedicated to creating and strengthening a mutually beneficial relationship between MIT and corporations worldwide. Established in 1948, the ILP continues to be a key player in making industrial connections for MIT. Over 200 of the world's leading companies partner with the ILP to advance research agendas at MIT.

With continued acceleration of advancements in technology and knowledge discovery, and a more demanding corporate funding environment, the ILP is committed to creating productive interactions with industry. The ILP continually evolves to meet the interest, needs and aspirations of MIT faculty and corporate partners.

ILP members get many benefits with their registration, to include:

- Knowledgebase website
- Research reports
- Conferences (members will receive emails of upcoming conferences, workshops and research news)
- Videos and presentation material from the last 10 years of conferences
- On-campus meetings with MIT faculty

A high-dynamic range image of the dome at the Massachusetts Institute of Technology campus in Cambridge, Mass.

Some of the academic disciplines to take advantage of at MIT that would apply to Carderock researchers include artificial intelligence, biological engineering, bioengineering, metallurgy, nanoscale research for sensors and sensing systems, new materials, advanced manufacturing, environmental remediation, electronic fabrics, quantum science and engineering, 3D printing, augmented reality and structural health monitoring.

Face-to-face discussions with MIT faculty and researchers are the most highly valued service the ILP provides, as these interactions often sow the seeds of successful collaborations. The ILP will actively advocate for Carderock Division's research and strategic agenda on campus and secure substantive meetings with key faculty and researchers.

The Industrial Liaison Officer (ILO) provides continuity and serves as the facilitator to move discussions along and work with both Carderock Division's representatives and faculty to enable mutually beneficial outcomes.

The ILO, a veteran MIT insider, will be well-briefed on Carderock Division's needs and objectives, will be perfectly positioned to advocate for its agenda on campus, quickly identifying and engaging the interest of relevant faculty.


OFF THIS

Nuclear propulsion director visits Carderock

Steve Ouimette, deputy head for the Hydrodynamics and Engineering Department at Naval Surface Warfare Center, Carderock Division, gives a tour to Adm. James (Frank) Caldwell, director for the Naval Nuclear Propulsion Program, of the David Taylor Model Basin during his visit June 5, 2018, to Carderock's West Bethesda, Md., headquarters. (U.S. Navy photo by Nicholas Brezzell/Released)

Qatar Navy visits Carderock

Capt. Mark Vandroff, Naval Surface Warfare Center, Carderock Division commanding officer, discusses a ship model with members of Qatar Navy's leadership on July 13, 2018, in West Bethesda, Md., as part of a week-long visit to other Navy commands. (U.S. Navy photo by Nicholas Brezzell/Released)

Carderock honors Warfare Center award winners

Rear Adm. Tom Anderson (right), commander of Naval Surface Warfare Center, presents Warfare Center awards during a visit on Aug. 15, 2018, to Naval Surface Warfare Center, Carderock Division in West Bethesda, Md. Pictured from left, Carderock Commanding Officer Capt. Mark Vandroff, award recipients Jeevan Nalli, Jared Soltis, Christopher Perich, Laurent Edgell, Eric Silberg, Brittany Preston-Baker, David Rich, Randy Lang, Eugene Reed, Alexis Hargro, Kevin Hale, Virginia Miele, Steve Szpara, James Mulford, Stephen Shepherd, Kevin Lin, Alexander Tsarev, Jason Delisser and Anderson. (U.S. Navy photo by Devin Pisner/Released)

Magnificent

Carderock's annual award ceremony, the "Magnificent Eight"

By Brooke Marquardt,
Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division hosted the 19th annual honor awards ceremony, the "Magnificent Eight," on Aug. 28, 2018. Employees who made a significant contribution to the Navy and Carderock Division in 2017 were honored by the West Bethesda, Maryland, command.

Gravely Award

The Vice Admiral Samuel L. Gravely Jr. Award for achievement in equity and diversity recognizes significant contributions to the promotion of understanding cultural differences and to furthering equal employment opportunity for all persons at all levels in the workplace.

This year’s recipient of the Gravely Award was Stephanie Ferrone, a physicist in Carderock’s Underwater Electromagnetic Signatures and Technology Division, for her dedication to removing barriers to equal employment opportunities while increasing organization diversity within the division. As an active member and leader of the Equal Employment Opportunity Advisory Committee, Ferrone regularly participated in a process called “workforce sensing” to determine the way ahead to ensure all employees are provided with sufficient opportunities throughout the course of their careers.

Stephanie Ferrone receives the Vice Adm. Samuel L. Gravely Jr. Award for achievement in equity and diversity at the Carderock Division Honor Awards ceremony Aug. 28, 2018. From left: Commanding Officer Capt. Mark Vandroff; Ferrone; Mike Slater, division head of Carderock’s Signatures Measurement Technologies and Systems Division; and Dr. Paul Shang, Carderock’s acting technical director. (U.S. Navy photo by Nicholas Brezzell/Released)

“It is somewhat daunting to be among the group of award recipients today, who represent technical excellence across the entire division, especially for an award that is for equity and diversity, rather than for technical excellence,” Ferrone said. “In reflection, however, I realized that an award for diversity belongs among these awards because diversity and equity are truly the foundation of the advancements that we as a division make in the technical field.”

Hopper Award

The Rear Adm. Grace M. Hopper Award recognizes outstanding accomplishments in organizational support that result in developing or improving a critical product or process.

Rita M. Terhaar, Carderock’s Human Resources director, received the Hopper Award for her leadership in building a fully functional Human Resources Division capable of supporting the command following the separation of the Philadelphia site from Carderock Division when it was established as its own Echelon IV Command in 2015.

Rita M. Terhaar, Carderock’s Human Resources director, receives the Rear Adm. Grace M. Hopper Award for excellence in organizational support at the Naval Surface Warfare Center, Carderock Division Honor Awards ceremony Aug. 28, 2018, in West Bethesda, Md. From left: Commanding Officer Capt. Mark Vandroff; Terhaar; Tamar Gallagher, head of Carderock’s Corporate Operations Department; and Dr. Paul Shang, Carderock’s acting technical director. (U.S. Navy photo by Nicholas Brezzell/Released)

“We’ve built some robust programs for supervisors and employees, and nobody does that alone," Terhaar said. "I have to thank my team of dedicated human resources specialists who stood beside me as we built this office."

The MK 18 Mod 2 Lithium Battery Test Team receives the Rear Adm. Benjamin F. Isherwood Award for exceptional fleet support at the Naval Surface Warfare Center, Carderock Division Honor Awards ceremony Aug. 28, 2018, in West Bethesda, Md. Members of the team are, pictured left after Commanding Officer Capt. Mark Vandroff: Earl Armstrong, Adam Dolezal, Thomas Hays, Louis Levine, Jacob Helmers, Jessica Schwartz, Joseph Praydis, Julie Anne Simmons and Usman Sorathia. Also pictured is Dr. Paul Shang, acting technical director, and Jeff Mercier, head of the Platform Integrity Department. Awardee Christopher Mealy is not pictured. (U.S. Navy photo by Nicholas Brezzell/Released)

Isherwood Award

The Rear Adm. Benjamin F. Isherwood Award recognizes innovation and expertise in the effective assessment, development, execution or deployment of technological solutions for operational fleet needs.

The award was presented to the MK 18 Mod 2 Lithium Battery Test Team for their successful evaluation of a transport and charging container for the MD 18 Mod 2 Unmanned Underwater Vehicle (UUV). During the execution of three large-scale, lithium-ion abuse simulation tests, the robust container design demonstrated its tolerance to heat, flames and venting combustible gases, generating the data required to make the decision to deploy the container to the field.

"When people ask me what it is that Carderock does, it boils down to three things: they use science and engineering to make our warfighters more lethal, more efficient and safer. The Lithium Battery Test Team is an example of a project that does all three," Carderock Commanding Officer Capt. Mark Vandroff said.

The Computational Research and Engineering Acquisition Tools and Environments (CREATE) – Ships Team receives the Vice Adm. Emory S. Land Award for collaboration excellence at the Naval Surface Warfare Center, Carderock Division Honor Awards ceremony Aug. 28, 2018, in West Bethesda, Md. The team members, who came from all the technical codes at Carderock. are: Dr. Shawn Aram, Raymond DeFrese, Dr. Keegan Delaney, Dr. John Gilbert, Dr. Alexander Gray, Todd Heidenreich, Jeffrey Hough, Dr. Jun Li, Dory Lummer, Michael Miraglia, Cathy Ngo, Dr. Bong Rhee, Cullen Sarles, Dr. Hua Shan, Jonathan Stergiou, Richard Van Eseltine, Dr. Abel Vargas and Wesley Wilson. (U.S. Navy photo by Nicholas Brezzell/Released)

Land Award

The Vice Adm. Emory S. Land Award recognizes an individual or small group that has made significant contributions by establishing new relationships, fostering communication and promoting the value and benefits of collaborative working relationships at all levels.

The Computational Research and Engineering Acquisition Tools and Environments (CREATE) – Ships Team was presented the Land Award for the successful development of software tools that advance the ship design and analysis process by delivering new and enhanced capabilities into the hands of ship and ship system designers.

"We've got a fantastic team and working with them and working on some excellent technology has been great," said Jeff Hough, Carderock's distinguished engineer for ship design. "It's an honor to be recognized for this work, and they're making a difference on acquisitions programs."

McCormack Award

The Donald F. McCormack Director's Award for Warfare Center collaboration recognizes a small cross-Warfare Center Division team that has made significant contributions by establishing new relationships, fostering communication and promoting the value and benefits of collaboration.

The LHA 6 Total Ship Survivability Trial Team receives the Donald F. McCormack Award, which recognizes a small group for collaboration excellence across the Warfare Centers, at the Naval Surface Warfare Center (NSWC), Carderock Division Honor Awards ceremony Aug. 28, 2018, in West Bethesda, Md. From left: Commanding Officer Capt. Mark Vandroff; NSWC Carderock's Laurent Edgell, Jeevan Nalli, Christopher Perich and Michael Persinger; NSWC Philadelphia's Hannah Demboski and Robert High; Jeff Mercier, head of the Platform Integrity Department; and Dr. Paul Shang, acting technical director. (U.S. Navy photo by Nicholas Brezzell/Released)

The LHA 6 Total Ship Survivability Trial (TSST) Team, which included members from both Carderock and Philadelphia divisions, was awarded the McCormack Award for their successful execution of the TSST on USS America (LHA 6). Unique to this TSST, the ship's training team helped implement the scenarios, which saved the Navy approximately $1 million and provided the crew's Damage Control Training Team with integrated, realistic exercises that went beyond basic training.

"I couldn't have asked for a better team, you really knocked it out of the park," said Laurent Edgell, an engineer in Carderock's Vulnerability Assessment Branch. "There are a lot of challenges executing such a large test. We had over 1,800 implementations, any of which could have derailed the test, but we came away with significant insight. No one was injured and we didn't damage any equipment, so the collaboration was well done and vital."

Melville Award

Scott Black, head of the Computational Fluid Dynamics Division, accepts the Rear Adm. George W. Melville Award for engineering excellence on behalf of naval architect Stephen Neely, who was not able to attend, at the Naval Surface Warfare Center, Carderock Division Honor Awards ceremony Aug. 28, 2018, in West Bethesda, Md. From left: Commanding Officer Capt. Mark Vandroff; Black; Steve Ouimette, deputy head of the Naval Architecture and Engineering Department; and Dr. Paul Shang, acting technical director. (U.S. Navy photo by Nicholas Brezzell/ Released)

The Rear Adm. George W. Melville Award recognizes outstanding engineering contributions in the application of knowledge toward research and development of materials, devices and systems or methods including design, development and integration of prototypes and new processes.

Stephen Neely, a naval architect in Carderock's Computational Propulsors Branch, earned the Melville Award for his achievement as the Navy's lead submarine propulsor designer working on the Ohio-, Virginia- and Columbia-class propulsors, as well as new submarine propulsors and concepts. One of Neely's largest contributions to the Navy propeller and propulsor community is the development of a suite of geometric modeling tools that can robustly define

Dr. Timothy Coats, lead for Combatant Craft Division's Unmanned Maritime Mobility Group, receives the Capt. Harold E. Saunders Award for exemplary technical management at the Naval Surface Warfare Center, Carderock Division Honor Awards ceremony Aug. 28, 2018, in West Bethesda, Md. From left: Commanding Officer Capt. Mark Vandroff; Coats; Steve Ouimette, deputy head of the Naval Architecture and Engineering Department; and Dr. Paul Shang, acting technical director. (U.S. Navy photo by Nicholas Brezzell/Released)

complex and subtle propulsor features.

"For the past year, Neely has had a plan to take the summer off and sail his boat up to Canada," said Scott Blake, Neely's division head, who accepted the award on Neely's behalf. "He sent us some words to us in receipt of this award: 'I've been at Carderock for the past 29 years, and one thing that has always impressed me about this place is how long people stick around. It says a lot about the jobs that we have, and the work that we do.'"

Saunders Award

The Harold E. Saunders Award recognizes exemplary achievement in leadership of a major technical area or management of a complex technical project. This year, there was a tie for the Saunders award.

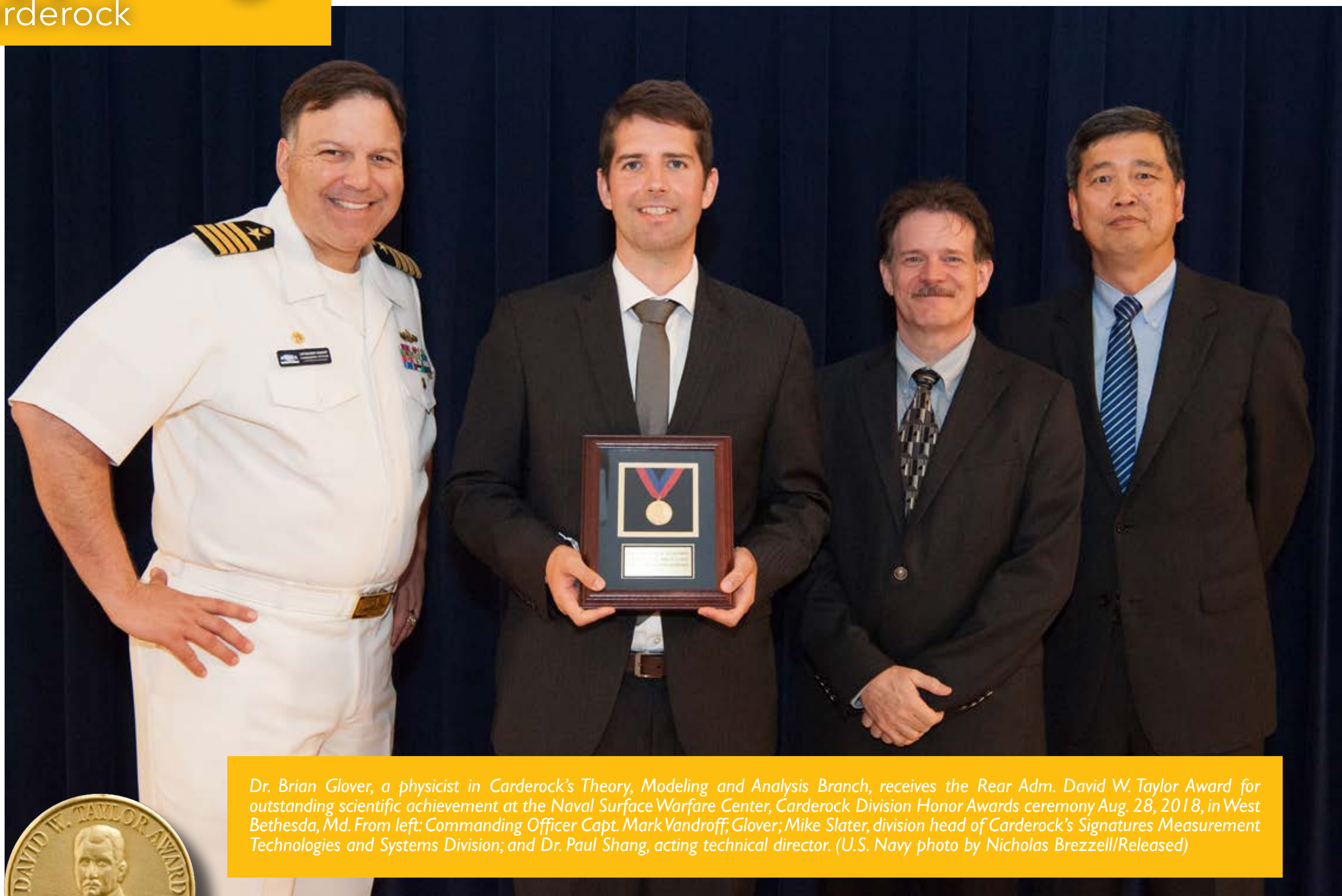
Dr. Timothy Coats, lead for Combatant Craft Division's Unmanned Maritime Mobility Group, was awarded the Saunders Award for his successful leadership of a high-performing team advancing Unmanned Surface Vessel (USV) capability.

"I've got a great team. Their success is my success," Coats said. "When we started this project in 2016, I gave them the name Unmanned Maritime Mobility Group, so when people ask them what they do, they respond, 'UMM...' They affectionately became known as the UMM-lings and they embraced my vision and made it their own."

Amy Le Doux, Carderock's customer advocate for the Virginia-class Program Office (PMS450), receives the Capt. Harold E. Saunders Award for exemplary technical management at the Naval Surface Warfare Center, Carderock Division Honor Awards ceremony Aug. 28, 2018, in West Bethesda, Md. From left: Commanding Officer Capt. Mark Vandroff; Coats; Mike Slater, division head of Carderock's Signatures Measurement Technologies and Systems Division; and Dr. Paul Shang, acting technical director. (U.S. Navy photo by Nicholas Brezzell/Released)

Amy LeDoux, Carderock's customer advocate for the Virginia-class Program Office (PMS 450), was presented the Saunders Award for achievements in her role as a customer advocate. Her knowledge of portfolio execution and expenditures allowed her to work with the program office to rapidly support assignment and completion of emergent tasking, resulting in a $10 million increase in tasking/funding provided to Carderock in fiscal 2018.

"I want to thank my leadership; they have allowed me to work independently while following my own instincts and taking initiative, all while letting me know that they have my back," LeDoux said, adding her thanks to the PMS 450 team. "We each bring different perspectives and skills to the table as we discuss priorities and solutions to issues without the risk of being judged."



Dr. Brian Glover, a physicist in Carderock's Theory, Modeling and Analysis Branch, receives the Rear Adm. David W. Taylor Award for outstanding scientific achievement at the Naval Surface Warfare Center, Carderock Division Honor Awards ceremony Aug. 28, 2018, in West Bethesda, Md. From left: Commanding Officer Capt. Mark Vandroff; Glover; Mike Slater, division head of Carderock's Signatures Measurement Technologies and Systems Division; and Dr. Paul Shang, acting technical director. (U.S. Navy photo by Nicholas Brezzell/Released)

Taylor Award

Named for Carderock's founding father, the Rear Adm. David W. Taylor Award recognizes outstanding scientific contributions to the development of future maritime systems through the creation of technology based upon research.

The Taylor Award was presented to Dr. Brian Glover, a physicist in Carderock's Theory, Modeling and Analysis Branch, for leading the way in developing and applying science and technology to address current and future submarine design and engineering challenges. He led, conducted and participated in all aspects of signature technologies to reduce underwater electromagnetic signature of submarine platforms.

"I came from a Navy family. Both of my grandfathers served in World War II, and my father, retired Capt. Gray Glover, served on a destroyer in the first Gulf War," Glover said. "I'm very honored by their service, and the Navy has always provided my family with a good life that I've always been grateful for. I'm humbled and honored to have the leadership, mentors and coworkers. I've had my successes and I've had my failures, but I've always had great people here supporting me."
In his closing remarks, Vandroff said, "Today is a real testament to what we do here at Carderock, and all of the award winners should be immensely proud of the work they've done and are doing to help the warfighter, the tools that they put in the hands of the warfighter, and we should all feel lucky to be working in a place like this."

The awards nomination process and the ceremony were organized by Sue Rossi, Meg McConnell and Katisha McAllister of the Human Resources Division.

Carderock, National Intelligence University sign education partnership agreement

By, Justin Hodge,
Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division Commanding Officer Capt. Mark Vandroff and acting Technical Director Dr. Paul Shang signed an education partnership agreement (EPA) with the National Intelligence University (NIU) on June 11 in West Bethesda, Maryland.

The organizations will focus their research and development efforts on maritime technology and experimentation. Members of the Carderock team will also give educational guidance and assistance to their NIU counterparts while working side by side on a range of projects.

"There is an overlapping interest between Carderock and the National Intelligence University," said Dr. Peter Cho, an electrical engineer with Carderock's Maritime Systems Hydromechanics Branch and the partnership program manager for the EPA.
He said the partnership started with the understanding that

Naval Surface Warfare Center, Carderock Division Commanding Officer Capt. Mark Vandroff (center) and Technical Director (acting) Dr. Paul Shang (left) sign an education partnership agreement with Dr. J. Scott Cameron (right) president of the National Intelligence University, in West Bethesda, Md., June 11, 2018. (Seated from left) Shang, Vandroff and Cameron. (Standing from left) Carderock Marine and Aviation Division Head Steve Ebner, Carderock Patent Attorney Dave Ghatt, Carderock Director of Strategic Relations Dr. John Barkyoumb, NIU Professor Dr. Peter Leitner, NIU Dean of the School of Science and Technology Intelligence Dr. Brian Holmes, NIU faculty member MSG Angel Morales, Carderock Electrical Engineer Dr. Peter Cho, Naval Architecture and Engineering Department Head Mike Brown and Carderock Director of Technology Transfer Dr. Joseph Teter. (U.S. Navy photo by Nicholas Brezzell/Released)

the two institutions were working toward a common goal in the development of assets for the security of the nation, and that each could be more effective by forming an alliance to work on a solution.

"Our dean of engineering, Brian Holmes, has done a fantastic job leveraging partnerships like this for the university, where students have access to resources and programs that actually give value back to our partners," said Dr. J. Scott Cameron, president of NIU. "The same goes for our partners. Our job at the university is to bring the information we have and share that with Carderock, in turn adding value to the intelligence community and the broader national security mission."

Cameron said he appreciates that this partnership lends new opportunities for the university's students, as they have found it challenging to find scientists and engineers — with a wealth of knowledge — within a close proximity of their campus.
"I want to express my appreciation for this opportunity," Cameron said. "There is a commonality where students and faculty can engage with Carderock employees and utilize the expertise they have within our academic programs. It truly is a wonderful day when we can sign a partnership with an institution that has this immense depth of knowledge, expertise and facilities, and are willing to share that with the community."

Dr. John Barkyoumb, director of strategic relations at Carderock, is the EPA program lead. He said the program enables educational institutions the opportunity to partner with the Navy, increasing students' awareness in science, technology, engineering and mathematics (STEM) careers, which could potentially lead them toward a career in a Navy research facility.

The National Intelligence University is the 14th active EPA that Carderock currently has with colleges and universities.

Carderock holds Industry Day for area businesses

By Brooke Marquardt, Carderock Division Public Affairs

Naval Surface Warfare Center, Carderock Division hosted the Carderock Day for Industry on June 12. The event provided an overview of its missions and initiatives to more than 125 attendees from 85 small and large businesses.

Capt. Mark Vandroff, commanding officer, started off the conference by saying, "We want to give you a better understanding of what we do here at Carderock. We want to make your valuable time more effective by giving you our requirements while also understanding the capabilities of your companies so we can better work together into the future."

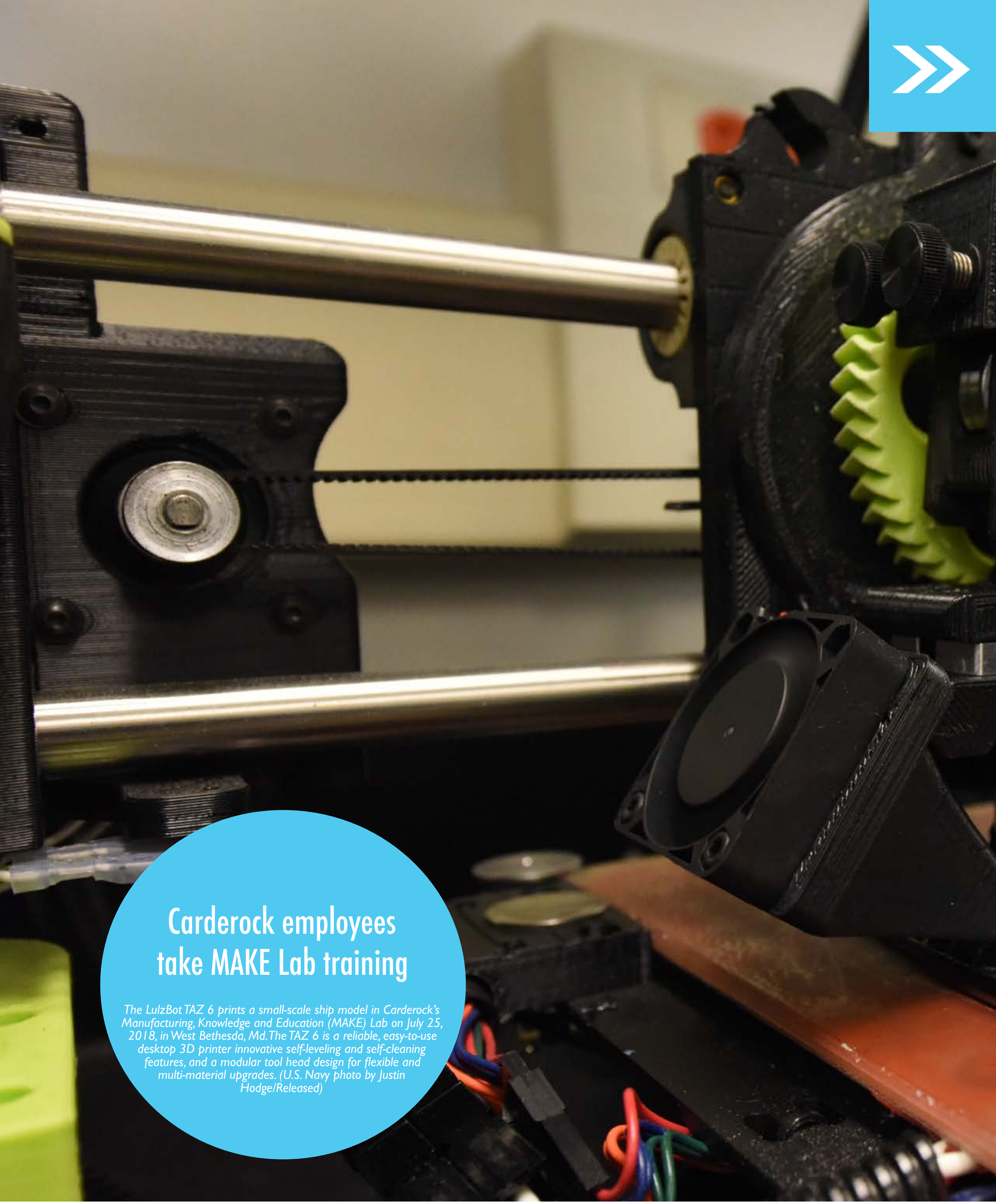
The full-day conference allowed business representatives to sit in on presentations containing vital information about current and future requirements for working with Carderock Division. It was also intended to enhance industry's understanding of Carderock Division, and to obtain their feedback.

"From a DOD perspective, one of the things we rely heavily on in the materials field is collaboration," said Johnnie DeLoach, head of Carderock's Materials and Manufacturing Division. "Since we do not have the capabilities of organizations with a much larger footprint, we leverage our partnerships at the warfare level, inter-agency level and those with other research facilities so we can provide the best solutions in our technical area."

In addition to Vandroff, Carderock Day for Industry speakers included: Tariq Al-Agba, head of the Contracting Department; Tamar Gallagher; head of the Corporate Operations Department,

Jeff Mercier, head of the Platform Integrity Department; Paul Luehr, deputy head for the Ship Signatures Department; Mike Brown, head of the Naval Architecture and Engineering Department; and Deputy Director for Small Business Programs Chris Jones, event organizer.

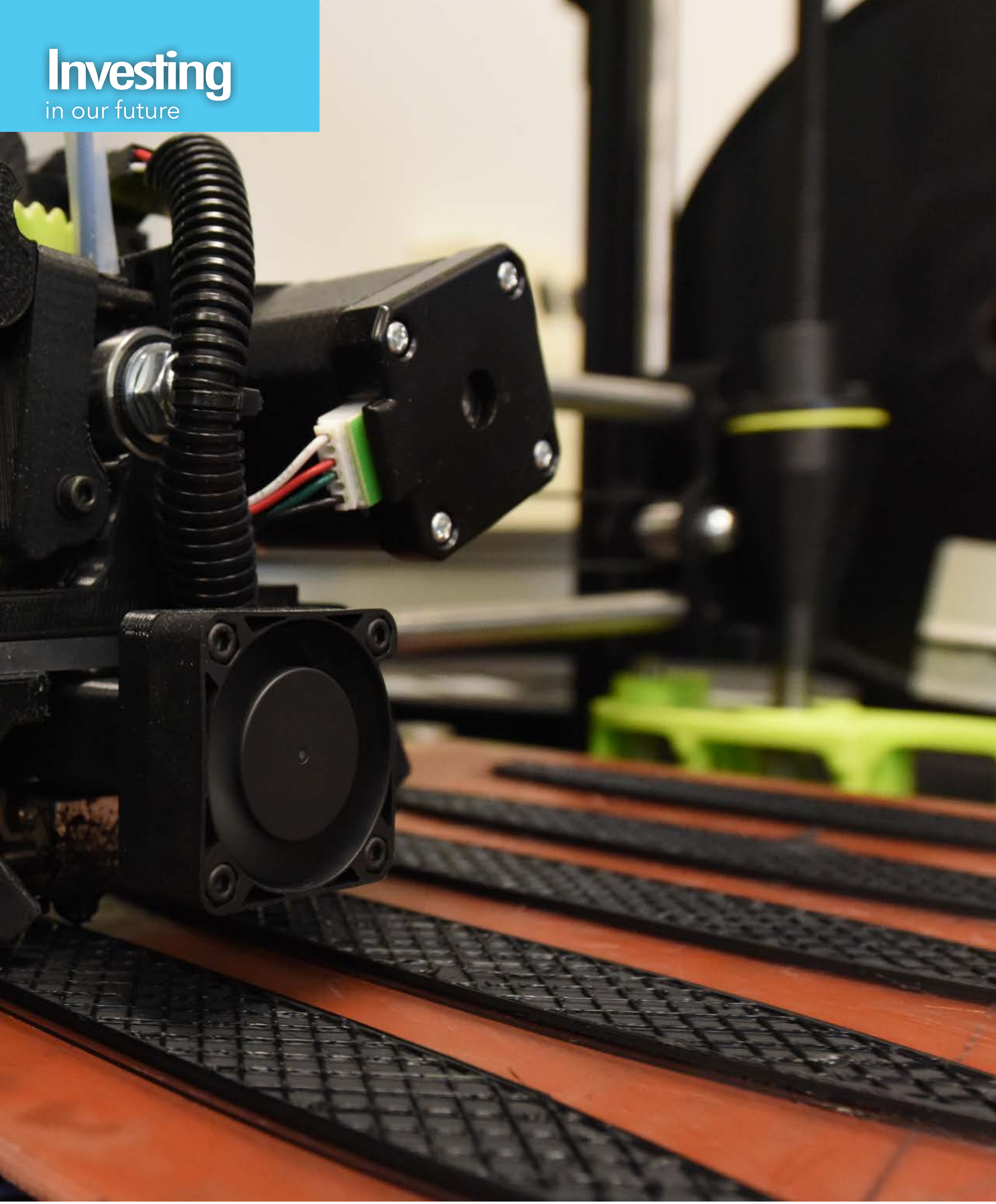
Capt. Mark Vandroff, commanding officer, Naval Surface Warfare Center, Carderock Division, gives opening remarks to more than 125 representatives of large and small businesses during Carderock's Industry Day in the Melville-Taylor Auditorium in West Bethesda, Md., on June 11, 2018. (U.S. Navy photo by Nicholas Brezzell/Released)



Carderock employees take MAKE Lab training

The LulzBot TAZ 6 prints a small-scale ship model in Carderock's Manufacturing, Knowledge and Education (MAKE) Lab on July 25, 2018, in West Bethesda, Md. The TAZ 6 is a reliable, easy-to-use desktop 3D printer innovative self-leveling and self-cleaning features, and a modular tool head design for flexible and multi-material upgrades. (U.S. Navy photo by Justin Hodge/Released)

Investing
in our future



A Design Space Generation Approach for Advance Design Science Techniques

Jason D. Strickland, Ph.D., Thomas E. Devine, Ph.D. and Jonathan P. Holbert,
Naval Surface Warfare Center, Carderock Division, West Bethesda, Maryland

ABSTRACT: The focus of this paper is to introduce a novel approach to support ship conceptual design efforts. This approach leverages a baseline set of hull lines and systematically varies this hull to create a design space. This subsequent design space is evaluated for resistance and powering, stability, and seakeeping. This approach develops a robust design solution space. Evaluation of the space allows for the development of objective, quantifiable information in advance of a final hull form selection. This data directly supports multiple design science approaches such as Set-Based Design (SBD), Design Building Blocks (DBB), and Bin Packing Algorithms. These approaches to ship design provide solutions to design problems which are often subject to a high degree of uncertainty or late stage design changes. An attractive aspect of broad design space evaluation is the ability to concurrently develop design information at varying levels of fidelity using communication variables and set negotiations. This then allows the designer to assess and reduce the design space based on feasibility and dominance supported by objective evidence.

1 INTRODUCTION

The development of the design space to be analyzed was a multistep process that heavily leveraged the scripting of existing software packages, within an integrated team environment, augmented with various concurrent engineering heuristics. The scripted portion of this process consisted of four basic analytical steps that developed a portion of the database that was ultimately evaluated. This automatically generated data set was then appended with additional fidelity from traditional "hand-touch" operations and other assorted engineering applications. Section 2 DESIGN SPACE DEVELOPMENT of this document outlines the development, under lying assumptions, and presents some typical results. Section 3 APPLICATION of this document outlines the how the outline process can be applied to a larger design effort and coupled with other leading design approaches.

2 DESIGN SPACE DEVELOPMENT

The automated design space was developed in a three-step process. This process follows the subsection outline of this section. The initiation of this process was the development of a nominal "seed" point. A seed point or parent hull form is effectively the centroid of the excursion space. It is a converged design point that represents one possible solution to the design problem under evaluation. For this effort four seeds were identified. It is important to understand that these seeds need not be fully viable under the evaluation of perfect or more complete information. This is merely a process initiation point. This aspect will be highlighted in following sections. These seeds were selected in order to understand the implications of the inherited machinery architectures, and hull lines. All seeds were developed in accordance with the same baseline requirements.

2.1 *IDENTIFICATION OF BASELINE "SEED" PARAMETERS*

In order to initiate this analysis, the first order of business was to define a nominal stack up length for the seed. This stack up is the gross order of magnitude for the vessels overall length with consideration to the functional arrangement of the vessel's topside (Garner et al., 2015) or major machinery systems (McCoy, Smoot, Kuseian, Marshall, & Collins, 2013). Therefore, for a surface combatant a nominal stack up would proceed as follows from the stern towards the bow: Flight Deck → Hangar → Boat Bays → Deck House → Missile Compartment → Deck Gun → Anchor/Line Handling Area. This concept can be applied to any class of vessel, for example an OSV would likely resemble the following:

Cargo Deck → Crane/Cargo Handling Space → Boat Bays → Deck House → Flight Deck. At this juncture, once a nominal stack up length has been determined one should revert to traditional heuristics of Length to Beam (L/B) and Beam to Draft (B/T) in order to develop a set of principal dimensions that are consistent with other ships of the appropriate class/type under evaluation. The dimensional ratios typically employed for these heuristics fall between 4-10 and 1.8-4 (SNAME, 1967). These are only an initial data point since the dimensions will be modified independently thus modifying these ratios. The approach below does not exclusively produce geometrically similar hull forms.

The principal dimensions and dimensional ratios of the four seeds evaluated for this effort are present in Table 1.

Table 1 – Design Space intiation seed's principal dimensions and parametric data

	Seed 1	Seed 2	Seed 3	Seed 4
L (m)	147	150	150	144
B (m)	16	19	18	20
D (m)	10	12	11	11
T (m)	6.0	7.2	6.6	6.8
L/B	9.2	7.8	8.3	7.3
B/T	2.7	2.7	2.7	2.9
Δ (MT)	5,400	6,700	6,500	6,500

Since the stack up of these seeds were developed with a common set of requirements it is not surprising that the longitudinal length of the four seeds, are nearly identical. However, the variation of the hull shaping is evidenced by the fluctuation in the beam, depth, and displacement. Once nominal hull particulars were derived, a 3D surface model of each seed was developed in Rhino™ (Robert McNeel & Associates, 2018). Figure 1 - Figure 8 depict an isometric perspective and a profile elevation of each of seeds developed, respectively. The color scheme represented in the following renderings is consistent for all following figures within this document. Therefore, in all following graphics Seed 1 will be represented with green data points.

Figure 1 – Seed 1 Isometric Rendering

Figure 2 – Seed 1 Profile Rendering

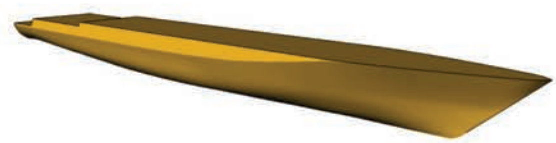


Figure 3 – Seed 2 Isometric Rendering

Figure 4 – Seed 2 Profile Rendering

Figure 5 – Seed 3 Isometric Rendering

Figure 6 – Seed 3 Profile Rendering

Figure 7 – Seed 4 Isometric Rendering

Figure 8 – Seed 4 Profile Rendering

These seeds were specifically chosen to evaluate the influence of the inherited machinery architecture and seakeeping of the relevant seeds. The machinery architectures are as follows: Seed 1 has two main machinery spaces with longitudinal separation, Seed 2 investigates a hybrid electric plant with adjacent main machinery spaces, Seed 3 has a single main machinery space, and Seed 4 has two adjacent main machinery spaces,. The baseline machinery architectures for each of the representative seeds is delineated in Table 2. The combination of the nominal hull forms and the baseline machinery architectures allows for the development of a converged design seed.

Table 2 – Initial machinery line up for the design space initiation seeds

	Seed 1	Seed 2	Seed 3	Seed 4
Propulsion Train	Twin Shaft CODAD (2) 5m CPP	Twin Shaft CODLAG (2) 5m CPP	Single Shaft COGAG (1) 5m CPP	Twin Shaft CODOG (2) 4m CPP
Prime Movers	(4) MTU 20V 8000 Diesels	(2) 3.7 MW ELE Motors (1) GE LM 2500+ GT	(2) GE LM2500+ G4 GT	(2) FM PA6B Diesels (2) GE LM2500+ GT
Genset	(4) MTU 12V 4000 SSDGs	(4) MTU 20V 4000 SSDGs	(2) RR MT5 SSGTGs	(3) CAT 3608 SSDGs

At this point, a nominal seed has been developed complete with main subdivisions allocations compliant with 3 compartment floodable length scenarios with an assumption of shell to shell flooding. Further, a nominal General Arrangement was developed in order to develop an understanding of the baseline seed with regards to available area/volume and weight centroids. This body of work was the entering argument to the Design Space Exploration Script (DSES). This script marks the debarkation point from traditional point design to Design Space Exploration.

2.2 *SYSTEMATIC DESIGN SPACE EXPLORATION*

The Design Space Exploration Script (DSES) was created using the Octave™ toolset (Arag, 2010). Its intended goal is to develop sets of data by systematically exploring the design space around initial seed points. The script has multiple functions which include the ability to perform hull form offset manipulation, assess intact and damage stability, generate a resistance estimate, match machinery plants, and calculate fuel requirements. Each of these functions are discussed in more detail below.

Various hull form characteristics are required as input, including offsets. The offsets are taken from the Rhino™ (Robert McNeel & Associates, 2018) surface models depicted in Figure 1 - Figure 8 and are input into the code as a set of points in a traditional coordinate system. Following import of the seed offsets, the script then performs linear scaling modifications on the parent hull form in one, two, and all three dimensions. A data set of morphed hull forms is then created. The baseline modification is (+/-) 20% in all three principal dimensions in 5% increments. This sampling scheme yields 729 unique hull forms for each seed. The range of principal dimensions developed with this perturbation scheme is outlined in Table 3 below.

Table 3 – Seed parametric space range for principal dimensions of Length, Beam, and Depth. Draft is equal to 60% of total hull Depth. Displacement is calculated in salt water at the corresponding Draft.

	Seed 1	Seed 2	Seed 3	Seed 4
L range (m)	118.0-177.0	120.0-180.0	120.0-180.0	115.0-170.0
B range (m)	13.0-19.0	15.0-23.0	14.0-22.0	15.0-24.0
D range (m)	8.0-12.0	9.6-14.4	8.8-13.2	9.0-13.6
T range (m)	4.8-7.2	5.8-8.6	5.3-7.9	5.4-8.2
Δ range (MT)	3,600-12,200	4,600-11, 500	3,300-11,200	3,300-11,200

2.3 *CONCURRENT ANALYSIS*

The aforementioned hulls were then directly passed to a Stability, Resistance and Powering, Seaway Motion, and Endurance Fuel analysis model for further evaluation. Again, the goal of this scripting was to develop a large data set that can be systematically perturbed and evaluated from a variety of disciplines in order to determine feasibility and dominance within the design space. The following subsections outline each of the topical areas. The approach applied and the results applicable to each of the discipline domains will be discussed.

2.3.1 *STABILITY*

An interface to the Ship Hull Characteristics Program (SHCP) was developed. SHCP is the US Navy's standard evaluation tool original developed in the 1960's for the evaluation of intact, damage and wind heel (M. Rosenblatt & Son, 1967). This program also produces stand curves of form and general hydrostatic data. Following the generation of the data set of modified hull forms, the offsets are then exported into a SHCP input file. The script then calls SHCP to perform intact and damage stability analysis. The analysis is run for each hull form at drafts ranging from 40% to 70% of depth. The results are then appended to the hull form database. In addition to the stability data, general hydrostatic values are recorded, which will be used as inputs for other steps in the analysis. Table 4 delineates the end of service life (EOSL) conditions with corresponding displacements, drafts, and vertical center of gravity to allowable vertical center of gravity ratio (KG/KGa). While the KGa is a direct function of the hull geometry, the individual KG for each hull was scaled from the seed designs using methodologies outlined by the Society of Allied Weight Engineers (Society of Allied Weight Engineers, 2001, 2007). It should be noted that not all of these conditions are ballast free. Seeds 1 and 3 both required ballast in the minimum operational (MINOP) condition in order to maintain intact stability. Seed 4 would require further analysis since it is at or near the stability limit.

Table 4 – End of Service Life (EOSL) particulars and stability heuristic for Design Space seeds in the Minimum Operating (MINOP) loading condition.

	Seed 1	Seed 2	Seed 3	Seed 4
ΔEOSL (MT)	6,300	6,500	7,000	7,000
Draft (m)	5.6	5.1	5.9	5.8
KG/KGa	1.0	0.94	1.0	1.0

Transverse metacentric height divided by the vessels beam (GMT/Beam) is a traditional heuristic for stability that has been employed for almost a century, if not longer. The first reference that could be located was from the 1920's (Hiatt, 1920). A nominal value of 5% has been used as a minimum for a multitude of craft types since that time (Faltinsen, 2006; Webster, Bates, Phillips, & Haag, 1920; Yun & Bliault, 2000). Figure 9 displays the design space developed with a hull prismatic parallelepiped versus the GMT/Beam ratio. It should be noted that not all of the hulls produced have a 5% GMT/Beam value. The hulls with a negative GMT to beam ratio would be unstable. The hulls between 0-5% have been identified as marginal and potentially too tender. Hulls above 20% have been identified as marginal and potentially too stiff. Subsequent analysis was isolated to a GMT/Beam range of 5-20%.

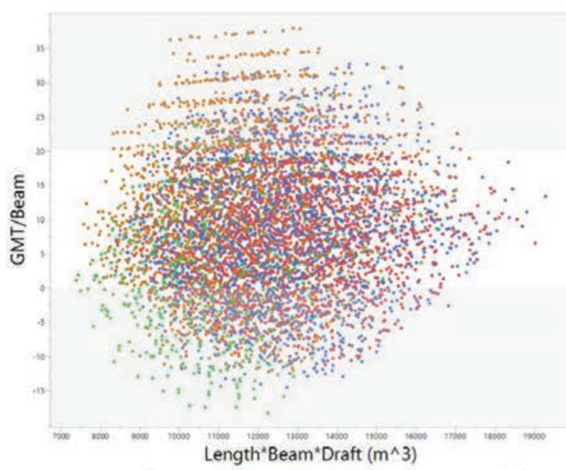


Figure 9 – Composite surrogate stability analysis for the developed design space.

2.3.2 *RESISTANCE AND POWERING*

Hull resistance was approximated through the use of the Transom Stern regression (S.C. Fung & Leibman, 1995; Siu C Fung, 1991). This calculation method was integrated in a similar method as in the Advanced Ship and Submarine Evaluation Tool (Kassel, Cooper, & Mackenna, 2010; Naval Sea Systems Command, 2012). This method provides a residuary resistance prediction for each hull form at a series of speeds. The frictional resistance coefficient is predicted using the ITTC-1957 frictional correlation line (Morrall, 1970). Appendage drag was estimated as a ratio of total resistance based on barehull and appended model test data of ships with similar appendage arrangements. Air drag was calculated per DDS 051 (Naval Sea Systems Command, 1984), with the windage area scaled off of the seed design. Using these data sets, the total resistance and required effective power are calculated for the entirety of the design space. The required power is the amount of power necessary to drive the hull at a given speed. Once the 2,916 hulls were paired with plausible powering solutions, outlined in Table 5, the design space blossomed to 37,250 design points. This larger space is displayed in Figure 10.

Table 5 - Powering configurations considered during this design space evaluation

Plant Configuration	Auxiliary Engine	Main Engine
COGAG-2	LM 2500 +	LM 2500 +
COGAG-1	RR MT 30	RR MT 30
CODAG-2	FM PA6B STC	LM 2500 +
CODAG-1	MTU 20V 8000	RR MT 30
CODAD	MTU 20V 8000	MTU 20V 8000
CODOG-2	FM PA6B STC	LM 2500 +
CODOG-1	MTU 20V 8000	RR MT 30
COGOG	RR MT 7	RR MT 30
CODLAG	3.7 MW Elec Mtr	LM 2500 +

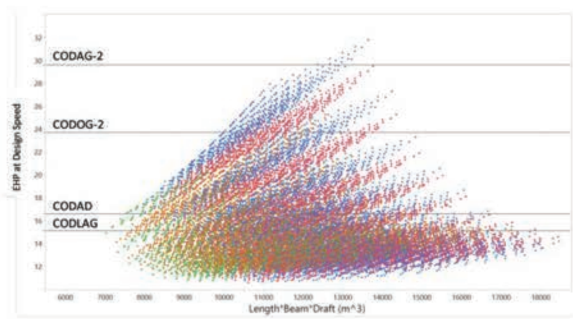


Figure 10 – Expanded Design Space of hull and power option permutations.

Figure 10 depicts the prismatic volume which can be correlated to a nominal full load displacement of the converged design point on the axis of abscissas, with the corresponding EHP at the design speed as the ordinate. The resultant trend is largely intuitive. The larger the vessel is with respect to displacement the more power is required to propel the vessel at a given speed. Additionally, for analysis purposes, iso lines of developed power have been added to the figure. These lines represent the powering configurations detailed in Table 5 above.

2.3.3 *SEAWAY MOTION ANALYSIS*

Seaway motion analysis was conducted with the Ship's Motion Program (SMP) (Meyers, Applebee, & Baitis, 1981). This program was utilized to generate roll amplitudes, pitch amplitudes, vertical accelerations, lateral accelerations, deck wetness instances, and hull slamming instances in a seaway conforming to Bretschneider spectrum (Bretschneider, 1959) for sea state 5 at the most probable modal period and the maximum significant wave height. Each hull machinery combination was evaluated with in the designated seaway. While these results were evaluated to the NATO STANAG 4154 (North Atlantic Treaty Organization, 2000) requirements for several missions, a desire to have a singular measure of performance for seakeeping necessitated the use of percentage time operable (PTO). The PTOs are calculated by applying mission criteria to a vessel response with an equal probability of occurrence for each speed, heading, and sea state combination. Figure 11 graphically displays the PTO for the Transit and Patrol Mission in the Gulf of Alaska. While this is a notably harsh environment, it can be seen that the majority of the design points fall between 60 and 80 percent operable.

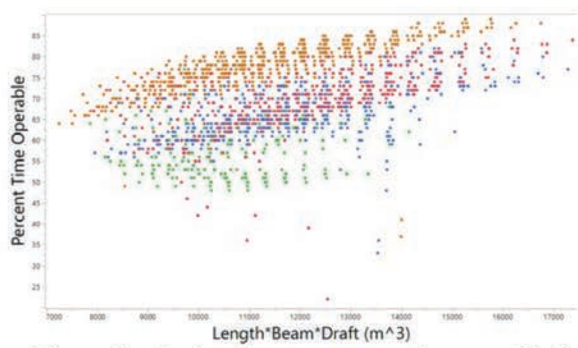


Figure 11 – Design Space percentage time operable for Transit and Patrol Mission in the Gulf of Alaska as a function of prismatic volumen

These are the same hull-machinery combinations that are plotted in the preceding figures. One can begin to see the potential of multi domain analysis of a common data set. This type of analysis is essential in informing the variable negotiations of Set Based Design (Singer, Doerry, & Buckley, 2009; Singer, Strickland, Doerry, McKenney, & Whitcomb, 2017; Sobek II, Ward, & Liker, 1999), and is directly attributable to system level definition that is required to realize a Design Building Block (Andrews, 2006, 2012; Andrews, McDonald, & Pawling, 2010) or Bin Packing (Depetro & Hoey, 2013; Duchateau, 2016; van Oers, 2011) approaches.

2.3.4 *FUEL LOADING CALCULATION*

An estimate for the economical transit fuel loading was calculated per DDS 200-1 (Naval Sea Systems Command, 2011). Power demand and electrical loading was estimated from previous efforts, however the effect of variations in the electrical plant was investigated. Figure 12 illustrates the effect of various electrical generator variants. This three-part graphic depicts the influence of generator selection. Once again, the x-axis is the prismatic hull volume, however, in this instance the vertical access corresponds to the economical transit fuel load required for an endurance range. The first column uses two Rolls Royce MT5 (Rolls-Royce, n.d.) aero-derivative engines as prime movers in a generator configuration combined with the main propulsion engines outline in Table 5. The cloud centroid of the first column is approximately 650 MT. The second column is the same data set with four MTU 12v4000 (Rolls-Royce, 2018) diesel engines, with a corresponding centroid of approximately 400 MT. The final column utilizes four MTU 20v4000 diesel engines (Rolls-Royce, 2018). This column is centered at approximately 450 MT due the common electrical loading referred to earlier. However, this plant lineup was developed for a combined diesel electric and gas turbine (CODLAG) arrangement. This machinery architecture had less commonality with the other seeds resulting in a sparse design space depicted.

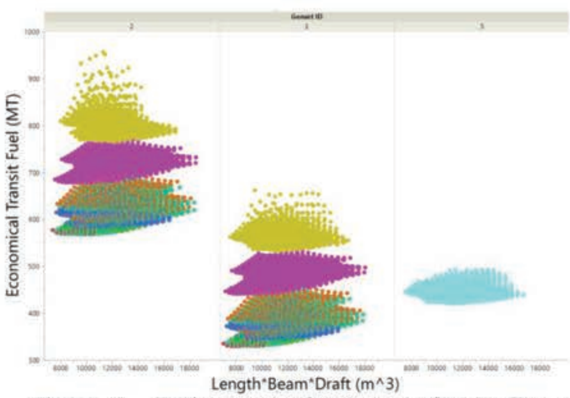


Figure 12 – Design space of endurance fuel loading as influenced by machinery selection

3 APPLICATION

The developed approach creates a design space that is analyzed from a traditional hull centric perspective. Intact and Damage Stability, Resistance and Powering, Seakeeping and Seaway Motions, and Endurance Fuel Requirements are all direct functions of the hull geometry. This systematic approach is a departure from the traditional design spiral of ship design because no selection has been made at this point. The design space was developed to understand trends and interdependencies inherit to this convoluted problem of ship design.

This approach leverages the philosophy of Set Based Design of decisional deferral. While it is true that an initiation point was selected, one can effectively argue that all design endeavors: “Begin with the end in mind” (Covey, 1990). While the exact realization of what that end may be is undefined the general product type is known at the onset of the activity.

Further while it is not the focus of this paper, structural section requirements, electrical power loading, heating ventilation and cooling, general arrangements, and detailed weight estimation occurred concurrently with the approach documented herein. These efforts were examined in detail for the seed location and scaled accordingly or discretely calculated for the points within the cloud.

This is where the Design Building Block or Bin Packing approaches have an application point. Since these both focus on the development of functional blocks and understanding the internal compartmentation of the vessel via an inside-out design practice. This would consume the bulk of the effort outlined in the preceding paragraph and directly support the development of weight centroid data. One can see how this outside-in approach could benefit from trade space development or automation of the internal components and compartments of a vessel.

Further since the DSES utilized spiral development, the volume and weight of the auxiliary systems continued to improve as additional information became available. It is rather easy to envision an instance that as the weight centroids continued to evolve that a feasible hull becomes unfeasible from a stability perspective. Much of this could be mitigated with the employment of inside-out approaches such as DBB or Bin-Packing approaches. Another such learning point could be volumetric constraints. As system detail is developed and refined a hull becomes volumetrically deficient to support the desired subsystem arrangement. Again, this is where an approach that focuses on the detailed development of sub compartment would lend tremendous dividends. Under the traditional design spiral approach, it would be necessary at this point to start over with a new set of principal dimensions.

However, the value of this approach is proven in this exact circumstance. Since a multitude of hulls have been evaluated for critical parameters, if a stability or volumetric constraint is active and drives the preferred hull into an unfeasible space. There are 728 other hulls of that exact format and 2,915 hulls of a compatible format that are already at the same level of analysis available to default towards.

Joining this scripting approach with another process that focuses on the development of higher quality auxiliary system design and automation of weight accounting would be a powerful step for naval architectural conceptual design endeavors.

4 CONCLUSION

Under this effort, a surface vessel design space was developed and analyzed from multiple domains in a robust fashion. This process consisted of four basic analytical steps that developed a portion of the database that was ultimately evaluated. 2,916 individual hull forms were evaluated from a seakeeping, stability, seaway motions, and endurance fuel perspective. This automatically generated data set was then appended with additional fidelity from traditional "hand-touch" operations and other assorted engineering applications.

Insights developed during the execution of this initial tasking were extremely helpful for scoping the global size and performance of a notional vessel. This effort was helpful for narrowing the trade space and facilitating preliminary design efforts. Deficiencies that were uncovered during the execution of this tasking included several things that would support interdisciplinary, collaborative activities. Some of these deficiencies would include the ability to perform set negotiation, and the preemptive development data structures. There is also a need for the development of sufficient understanding of sub-blocks and system level details. This understanding can be supported by DBB and Bin-packing algorithms, since they focus on this level of detail.

Further work could be performed on the development of structural systems, overall scoring metrics, and visualizations. While these activities have been handled outside of the initial synthesis loop, one can easily see the benefit of their inclusion. Finally, since this is a conceptual design tool, some assessment of risk would be greatly beneficial. This is currently accomplished via expert opinion. A means to objectively score the design risk, associated with the entirety of the space would potentially yield intriguing insights and should be evaluated further.

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