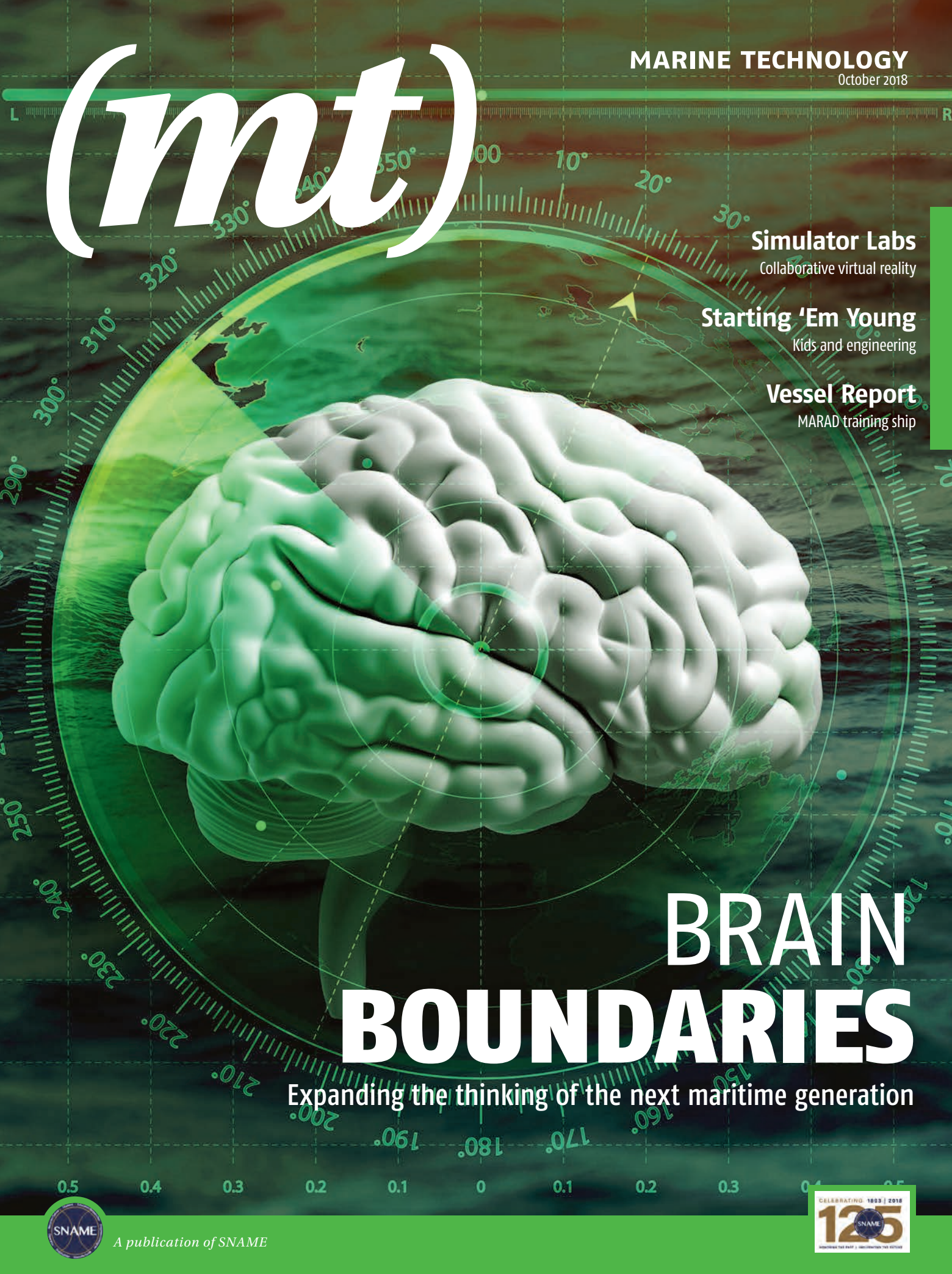
MARINE TECHNOLOGY
October 2018

(mt)

Simulator Labs
Collaborative virtual reality

Starting 'Em Young
Kids and engineering

Vessel Report
MARAD training ship



BRAIN BOUNDARIES

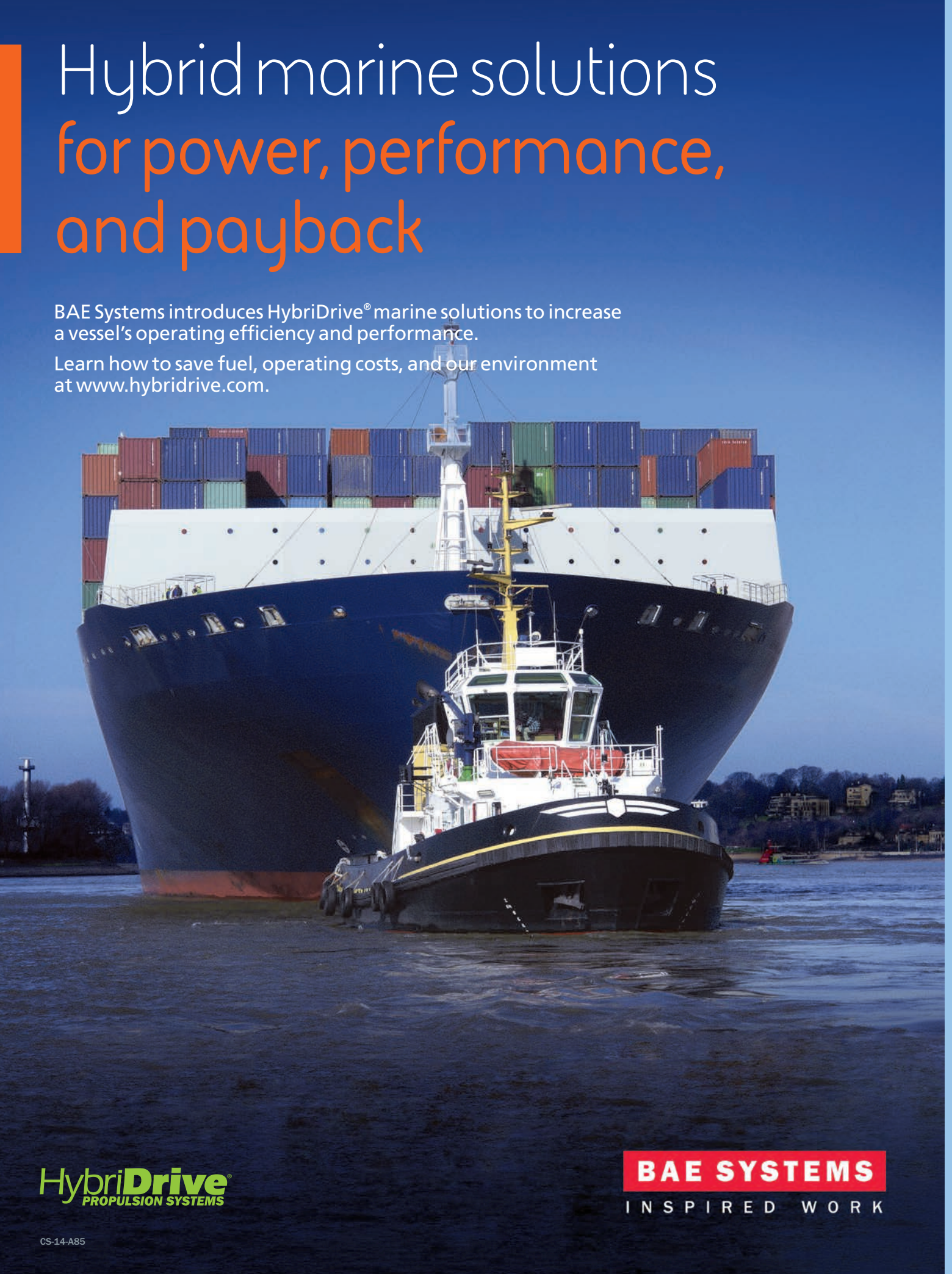
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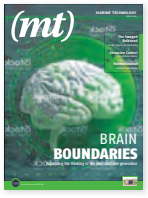


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Craftsmanship, Scholarship, and Leadership

BY JENNIFER R. RYAN

How Newport News Shipbuilding is preparing men and women for careers in the maritime community



ON THE COVER:
The path to successful education and training in maritime runs right through innovation country. That means pushing the envelope with creative programs, content, and thinking.
COVER DESIGN BY BATES CREATIVE

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The Mind Expansion Thing

Press releases and marketing pieces about educational and training programs come across my desk (okay, my monitor) on a regular basis, and occasionally I actually read them. (A cool photo of technology or a ship helps.) Sometimes, the curriculum or training strikes me as familiar, and I think, "Didn't I see something about Fill-in-the-Blank University or XYZ Company doing something like this?"

If my memory is on the ball, there is indeed a connection between what a company is working on and what an educational institution is offering. When the connection actually takes the form of collaboration between the maritime industry and academia, new audiences can be reached. "We've been able to be successful with a partnership with Mississippi Gulf Coast Community College," Anna Bourdais told me recently. "We wouldn't have been able to do that as a standalone organization. But through collaboration, through pooling our resources and creating synergy, we've been able to do that."

Bourdais knows whereof she speaks. As manager of learning and development at Ingalls Shipbuilding in Slidell, LA, she designs and develops programs that train, coach, and mentor people, and partnerships are a big part of the equation. That's why we asked her to work with us on this issue of *(mt)*: to identify and reach out to others who are on the front lines of educating and training both young people and those with more experience in the maritime sector.

> "It's not a single partnership...it's a network of partnerships."

"We're tapping into our local schools, to our high schools and local middle schools," she said when I asked her about other Ingalls programs. "We're trying to build our bench strength by getting the word out there and using it as not only as community outreach, but also as a potentially attractive option. It's through lots of partnerships, such as with SNAME or with NSRP. It's not a single partnership...it's a network of partnerships."

This issue of *(mt)*, with a focus on education and workforce development, wades right into these kinds of partnerships and programs. I think you're in for a little mind expansion as you learn how these organizations, technologies, and teachers are attracting and developing the present and the future of the maritime sector.

"The opposite of this is isolation, which probably would lead to being obsolete," says Bourdais, "because there are others out there who are collaborating on multiple levels, who are creating networks, helping one another to build and sustain. The idea is openness."

Douglas R. Kelly
Editor

Coming Attractions

The January 2019 issue of *(mt)* magazine will focus on modularity, flexibility, and adaptability in the design stage. It's shaping up to be a killer issue, so be sure to warm up and stretch before you read it.

And if you're not yet registered for the 2019 SNAME Maritime Convention, in Providence, RI, it's not too late. Go to snameconvention.com for details. You gotta go.

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October 2018

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(feature contributors)



Roger I. Basu is a structural engineer with more than 45 years of experience, most of which was spent on ships and offshore installations working in the U.K., Canada, and the U.S. His recent experience includes teaching at Webb Institute for 2 years and before that, he was with the American Bureau of Shipping in Houston, TX for 15 years. He is president of his own company in Toronto working on training, teaching, and consulting assignments.



Emily DeRocco is owner of a Washington, D.C.-based consulting practice linking education, workforce, and economic development assets for competitive advantage. In addition to her reform work with state and local officials, during the past five years, she has served as an officer and director of education and workforce for the Detroit-based manufacturing innovation institute; as director of the National Network of Business & Industry Associations for Business Roundtable; and as a member of several higher education institutions' boards.



Thalía Krüger is a naval architect and marine engineer with 20-plus years' experience providing innovative strategies and precise execution of complex maritime/offshore projects while delivering technical and project management expertise to diverse multidisciplinary teams. She works for ABS as manager global offshore, promoting and implementing ABS offshore business and services. She is an engaging mentor with a passion for the promotion of the naval architecture and marine engineering fields. She has been involved with SNAME for many years.



Chunyang Niu received a bachelor of engineering degree in marine engineering from Dalian Maritime University, Dalian, China, in 2017. He is pursuing a master of engineering degree in marine engineering from Dalian Maritime University. His research interests include marine engine room simulators and 3D monitoring of marine engine rooms. He has participated in a project of collaborative virtual reality training system for marine engineers from beginning to end. In this project, he was mainly involved in interface design and system debugging.



Peter Noble is a naval architect, and marine and ocean engineer with a wide range of experience in the marine and offshore industries. His career has included positions with shipyards; with ship and offshore design consultants; with offshore and marine research and development companies; with major classification societies; as chief naval architect with an international oil company; and currently as an independent consultant, advisor, and mentor, which includes engaging in lecturing and supporting student and young professional activities on a global basis.



Jennifer R. Ryan, PE, received her bachelor of science degree in naval architecture and marine engineering from Webb Institute in 1999, and she has been employed with Newport News Shipbuilding since the completion of her degree. While on educational leave in 2005, she received her master of science in naval architecture from the University of Michigan. She joined the faculty of The Apprentice School in 2006 as an academic instructor, and has been responsible for teaching advanced courses.



Dr. Susan Scurlock is the CEO and founder of Primary Engineer and its related programs, which expand from early years through to teacher-led research via the Primary Engineer postgraduate course. She is an Honorary Fellow of the Institution of Engineers and Shipbuilders in Scotland, a Fellow of the RSA, and a sister of the Hammermen. She is also the recipient of two honorary doctorates from the University of Strathclyde and Glasgow Caledonia University for her work in engineering education.



Yanghui Tan received bachelor of engineering and master of engineering degrees in marine engineering from Dalian Maritime University, Dalian, China, in 2013 and 2016, respectively. Currently, he is pursuing a Ph.D. in marine engineering from Dalian Maritime University. His research interests include marine engine room simulators, virtual reality, and 3D monitoring of marine engine rooms. He has participated in a number of virtual reality research projects in the laboratory led by Professor Jundong Zhang.



Jundong Zhang received bachelor of science, master of science, and doctor of science degrees in marine engineering from Dalian Maritime University, Dalian, China, in 1989, 1992 and 1998, respectively. He is a doctoral supervisor at the university. His research interests include marine engineering automation and control, integrated supervision, application of computer and network, marine engineering education, and electrical system design. He and his team have recently developed a series of advanced marine engine room simulators based on virtual reality technology.



Sibo Zhao received a bachelor of engineering degree in marine engineering from Dalian Ocean University in 2009. After graduation, he worked on a ship and in a shipyard. Currently, he is a marine engineer employed by Dalian Maritime University. His research interests include application of virtual reality on marine engine room simulators and marine engineering automation. He is mainly responsible for the construction of three-dimensional models in the project of collaborative virtual reality training system for marine engineers.

Reconnect in Providence



If you've been reading my messages here in *(mt)* lately, you'll know that I like to start by asking questions. Here are a couple of good ones. What have you done to keep yourself up-to-date with quickly changing technologies and regulations? And when is the last time you networked with 800 buyers, colleagues, and suppliers? You can do both at SNAME's Maritime Conference in Providence, RI, October 24-27. Think about it: meeting fellow associates you might not have seen in the last few years…taking a few extra days and visiting Newport and its mansions, like the Marble House or the Breakers.

And we have great speakers lined up for Providence. Kicking things off will be our keynote speaker for the opening session, Gary Jobson. A sailor, television commentator, and author based in Annapolis, MD, Jobson is a vice president of the board of Word Sailing. He is a graduate of SUNY Maritime College and has authored numerous sailing books, and is editor-at-large of both *Sailing World* and *Cruising World* magazines. He also is president of the National Sailing Hall of Fame.

Our Annual Banquet speaker will be the vice commandant of the United States Coast Guard (USCG), Admiral Charles W. Ray. He is second in command and directly oversees the USCG's senior operational and mission support commanders, as well as headquarters staff, and serves as service chief in the absence of the commandant.

Wrapping things up will be our closing speaker, Richard Balzano, deputy administrator of MARAD. Before being appointed to MARAD in 2017, Balzano served on active duty in the United States Navy in various assignments.

Looking ahead, we are working on many projects, from updating our books and reference materials to expanding our sections by becoming a truly international organization. We need you to volunteer to help us develop these and other programs in the coming year. Please get involved—and you can start by calling me at 860-490-1300, or by email at marty@toyen.net

Thak you for allowing me the privilege of serving as president and more importantly, thank you for supporting SNAME.

See you in Providence.

Martin Toyen
President of SNAME

Upcoming Events October–December 2018

OCTOBER 2018

Artificial Intelligence and Big Data—A Marine Engineering Perspective By Andrea Coraddu
October 12
ABS Europe, Ltd., London, England
Contact: snamewes16@gmail.com
The key point for the discussion will be the use of innovative data-driven approaches for vessel monitoring including remote assistance, condition-based maintenance on primary systems, and performance assessment/optimization on vessel operations.

Predictive Ship Operations and Maintenance: What's Next? by Iraklis Lazakis
October 12
ABS Europe, Ltd., London, England
Contact: snamewes16@gmail.com

Shipyard 4.0 and Internet of Ships, The IOT Applied to Shipbuilding by Rodrigo Perez Fernandez
October 12
ABS Europe, Ltd., London, England
Contact: snamewes16@gmail.com
Future smart ships and smart shipyards must be connected to the Internet of Things or they will not be smart. The shipbuilding process generates a lot of information and data, which makes it seem impossible to have all this data in real time. But the new processors, simpler and smaller, with a good connection to the Internet, make it possible.

SNAME Maritime Convention
Providence, RI
October 24–27
www.snameconvention.com
The SNAME Maritime Convention brings together the global maritime community's best and brightest minds to discuss, debate, and build the industry's future. Explore cutting-edge technical presentations, discover new products and opportunities, expand your network of leading international experts, and invest in your career.

NOVEMBER 2018

The Emerging Role of LNG in the Maritime Industry: A Young Naval Architect's Perspective by Hieu Le
November 19
Lloyd's Register
London, England
Contact: snamewes16@gmail.com

DECEMBER 2018

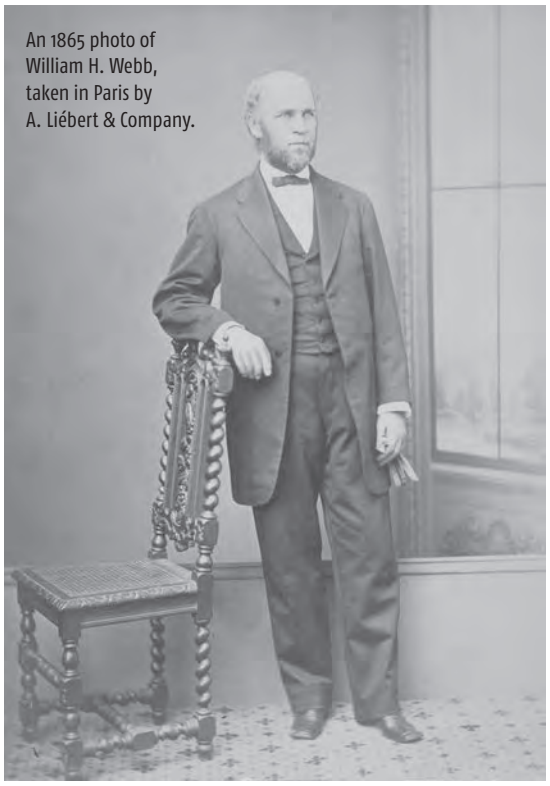
Fatigue and Fractures in Ship Structures by Roger I. Basu
December 11
Lloyd's Register
London, England
Contact: snamewes16@gmail.com

William H. Webb

Entrepreneur, leader, shipbuilder, philanthropist: the founder of Webb Institute was a man of many talents

BY BRIAN PETERSEN

William H. Webb is rightly remembered as an exemplary shipbuilder, successful businessman, and visionary philanthropist. Underlying these accomplishments is Webb as entrepreneur, relentless and innovative in his pursuit of opportunity. Webb's entrepreneurial leadership is manifest in his successes as proprietor of one of the world's most prolific shipyards between 1840 and 1869, during which time he oversaw immense progress in ship design and construction as America's first naval architect. It contributed to his role in several profitable ventures and strategic investments throughout his life. It informed his civic contributions, not least of which include the founding of a professional society and of a college both dedicated to the art and science of naval architecture. William H. Webb was an entrepreneur because he refused to be defined or constrained by his circumstances or the resources available to him, and this insight is critical for understanding his leadership and his ongoing legacy within the maritime community.



An 1865 photo of William H. Webb, taken in Paris by A. Liébert & Company.

Born in New York in 1816, Webb was a scion of the Industrial Revolution. His era was defined by the transition from mercantilism to industrial capitalism, from an economic system predicated on the principle of conservation of wealth to one that promised that ingenuity and labor would be engines of wealth creation. Whereas mercantilism fostered imperialism, colonization, and commercial and industrial activities coordinated by the state, industrial capitalism encouraged free trade, labor specialization, and commerce and industry restricted only by the whims of supply and demand.

This shift in economic perspective profoundly disrupted shipping and shipbuilding. Under mercantilism, nations built ships as a means to establish and preserve trade routes, maximize trade surplus, and accumulate tangible assets such as gold, silver, and spice. Capitalism, on the other hand, incentivized industrialists to pursue shipbuilding to access and serve new markets as a means of entrepreneurship and enrichment. Shipping and shipbuilding grew rapidly. In America, the growth of shipping was accelerated by territorial expansion in a collective national surge to manifest destiny. In the decade before the War of 1812, itself one of the last vestiges of mercantile thinking, the American territory nearly doubled in size as a result of the Louisiana Purchase, and the number of vessels in her merchant marine more than doubled. By 1820, approximately 90% of American foreign trade was carried in American-built ships, and by mid-century, the tonnage of America's merchant marine nearly equaled that of England's, which had long been the dominant seafaring nation in the world.

William H. Webb *continued*



Webb's Academy and Home for Shipbuilders in 1915. Photo courtesy of the Museum of the City of New York.

The Industrial Revolution didn't just increase demand for American shipbuilding. It also catalyzed the transformation of shipbuilding as art to shipbuilding as science. Slowly, sail gave way to steam, and then timber to iron and steel. Motivated by the era's economic incentives, craftsmen and engineers made substantial technological advancements across several disciplines foundational to ship design and construction; mechanics, hydraulics, metallurgy, and propulsion were chief among them. American innovator Robert Fulton personified the technological progress of the era when he launched *Clermont*, the world's the first commercially-successful steamboat. Like Fulton, William's father Isaac Webb took full advantage of the rising economic tides of the Industrial Revolution. Isaac apprenticed during the shipbuilding boom preceding the War of 1812, and after the war, he helped to construct a steamboat for Fulton's North River Steamboat Company. Later, Isaac assisted with construction of the world's second ocean steamship, appropriately and eponymously christened *Robert Fulton*.

Playground and laboratory

If the Industrial Revolution was the crucible of William Webb's entrepreneurship, Isaac's shipyard was a reagent. Located along the East River of Manhattan, the shipyard was Webb's playground and laboratory. Hem spent his vacations at the yard building and sailing boats with great enthusiasm. His leisure was well-deserved. Webb was a diligent student and he excelled academically, particularly in mathematics.

He successfully petitioned Italy to purchase two ironclad frigates, upon the delivery of which he was honored by the Italian government with the "Order of Saints Maurice & Lazaras."

Despite his scholarly aptitude, he relished being regarded as a mechanic, and by age 15, he had declared his intention to apprentice in his father's yard and learn the art of shipbuilding.

Entrepreneurs fail. What distinguishes the successful entrepreneur is resolve in defiance of adversity and failure. Webb's family and friends disapproved of his decision to pursue an apprenticeship, harboring higher aspirations for him given his academic achievements and concerned that he was too frail for shipyard work. Although ultimately not persuasive to Webb, these concerns proved prescient when he became seriously ill early in his apprenticeship. Undeterred by this setback, he recovered and persevered. For six years, he dedicated his days to laboring in the shipyard and his nights to calculating and drafting by candlelight. This period was formative for him. He had great commercial success during his apprenticeship, securing contracts to build five vessels before he completed his training. By the end of his apprenticeship, Webb had thoroughly mastered his craft, although he was dismayed at how difficult it had been to achieve this mastery. Later in life, he channeled these frustrations and used them in pursuit of his most impactful and lasting philanthropic efforts.

Technology entrepreneurs today expound the virtues of "eating your own dog food," or using your company's products. This practice establishes a feedback mechanism for managers, designers, engineers, and builders. It encourages empathy for the user, informs prioritization for project management, leads to better decision-making, and results in continuous product improvement. At age 23, Webb had the good fortune of embarking on a trip to Europe on the inaugural voyage of the vessel *New York*, a packet ship he had helped construct under one of the contracts he had secured as an apprentice. A contemporary report of this trip remarked that Webb "closely studied the performance of the ship, taking a practical interest in her working." He was esteemed throughout his life for a keen attention to detail and willingness to learn from his failures, and he would often attribute his success and reputation to these traits that today are so valued by entrepreneurs.

While in Europe, Webb surveyed the shipyards of England and Scotland. Just as Robert Fulton had benefited from his exposure to advanced applications of steam technology during his time in Europe, Webb too hoped to learn and bring to America the best practices from abroad. Unfortunately, his trip was punctuated by adversity when he learned that his father, Isaac, had died at age 46. Still only 23 years old, William hastily returned to New York and assumed management of his father's shipyard. To his dismay, he found the yard insolvent, news which he confronted with intensity and integrity. He developed a strategy to reorganize the shipyard for profitability and satisfy the debts owed to Isaac's creditors, with whom he met and convinced of the merits of his plan.

Rapid growth

Entrepreneurs are sometimes referred to as "growth hackers," individuals able to grow revenue rapidly through tenacious pursuit of business opportunities. Out of necessity, growth was William Webb's primary objective upon inheriting his father's yard in 1840. He executed his strategy to restore the shipyard to good fiscal standing by earning new customers and winning and delivering on lucrative contracts. Impressively, before building a



Webb Institute in 2012.

William H. Webb *continued*

His lessons in entrepreneurial leadership are many, and he remains a paragon for today's maritime professionals nearly 120 years after his death.

single vessel for one of his father's former customers, he built 10 for customers he had newly acquired. During his career, which spanned more than a quarter century, Webb's yard built 135 vessels. All were timber, some ironclad. By acclaim, he was the greatest shipbuilder of the 19th century for both the quality and quantity of his construction. His innovations were numerous, but his most important contributions were in the design and construction of steamships and clipperships.

His first steamship was *United States*, a 243 ft. sidewheel steamer with a displacement of 1,857 tons. Following its launch in 1848, *United States* was primarily intended to fulfill European mail contracts. She was a commercial success and holds the distinction as the first steamship to participate in trade with the city of New Orleans. That same year, Webb also built the steamship *California*, the first vessel delivered to the newly-incorporated Pacific Mail Steamship Co. Without a railway connecting New York to San Francisco until 1869, the California gold rush represented an enormous opportunity for mid-19th century American shipbuilding. Trade between America's east and west coasts was so lucrative that the capital required to build a vessel for this route could be recovered during her maiden voyage.

Unsurprisingly, Webb was on the vanguard of this opportunity. *California* was the first steamer to enter the Golden Gate to San Francisco, and her 46 years of service were testament to the quality of Webb's workmanship. In total, Webb delivered 11 steamships to the Pacific Mail Steamship Co., the last of which was the 3,836 ton *China*, one of the largest wooden commercial steamships ever built in America. In less than 20 years, Webb had doubled the tonnage of steamships constructed at his yard. He was responsible for a third of the steamships built in New York harbor during this period.

Webb enjoyed even more renown for his clipperships than he did for his steamships. During his career, he built more than a dozen clippers, delivering 5 in 1851 alone. Several of his clippers, including *Helena*, *Comet*, and *Swordfish*, set records for transit time during an era that prized vessel speed above all other design considerations. Amazingly, some of these transit records remain unbroken by vessels under sail. Builders of America's earliest pre-clippers in the 1820s and 1830s benefited from timber of higher quality and lower cost than that available to European shipbuilders. By the 1850s, however, American timber was dear as a result of deforestation, and American shipbuilders were left to compete with European vessels on the merits of design.

As much as any other American shipbuilder, Webb was prepared. His clipper designs were said to have employed the most judicious use of timber of all the major shipbuilders, a feat that he accomplished through clever and careful structural design. His clipper *Challenge*, for example, had unconventionally sparse framing fore and aft, relying instead on hull planking and diagonal iron strapping to achieve the requisite structural rigidity. Unburdened by this unnecessary displacement, *Challenge* returned from Shanghai with the most valuable cargo of tea and silk ever to be laden in one bottom. Webb's most endearing clipper, however, was *Young America*, widely considered the pinnacle of American clipper ship design. She boasted slender lines, elegant sheer, and a long and profitable service. Even Webb himself recognized the importance of his *Young America* as the culmination of the great age of the American clipper. Before her maiden voyage, he is reported to have implored one of her crew, "Take good care of her, Mister, because after she's gone there will be no more like her." *Young America* sailed for almost 33 years, an exceptionally long period for a clipper ship, before disappearing on a trans-Atlantic voyage in 1886.

Prominent owner

Although remembered primarily as a ship designer and builder, Webb also was a prominent shipowner and operator. He held stake in more than 50 vessels, many of which he had constructed. His holdings qualified him as one of the largest owners of tonnage in America. He made very lucrative investments in other industries as well, many of which shared synergy with his shipping and shipbuilding interests. For example, as compensation for the steamships he delivered to Pacific Mail Lines, he negotiated an ownership stake in the

Panama Railroad. Webb recognized that shipbuilding alone lacked the elasticity to meet the immense demand for trade between America's east and west coasts, and the rail was a way to augment available capacity to meet this demand. As another example of Webb being eager to "eat his own dog food," he was an investor in and a trustee of the Atlantic Insurance Company, which underwrote many of his ships. As the largest insurer of American shipping through the Civil War, it represented one of Webb's most profitable investments.

Entrepreneurship is sometimes referred to as the "gale of creative destruction," in recognition of the fact that the success of a new venture often comes at the expense of disrupting an incumbent. In the 1860s, after decades of following economic winds, the gale propelling American shipbuilding dominance died. Ultimately, several factors were responsible for the demise of shipbuilding in New York and throughout the eastern seaboard in America, but two in particular are noteworthy.

First, advances in metallurgy, coupled with increases in timber prices, resulted in iron becoming the preferred shipbuilding material. While the transition to iron, and later steel, was not an intrinsic impediment for American shipbuilding, America had imposed protectionist tariffs on iron imports, which put American yards at a significant disadvantage relative to their European competition. Second, a large surplus of ships and shipbuilding capacity existed after the Civil War, and demand from America's western expansion had waned with the end of the gold rush and the completion of a transcontinental railway. These market and political forces depressed American shipbuilding, and it never fully recovered.

Webb, for his part, foresaw the creative destruction awaiting American shipbuilding. He acted to preserve his shipyard's business interests, chairing a committee of New York City shipbuilders in protest of the federal iron tariffs. He also sought to diversify beyond American opportunities, pursuing the sale of warships to foreign governments. He successfully petitioned Italy to purchase two ironclad frigates, upon the delivery of which he was honored by the Italian government with the "Order of Saints Maurice & Lazaras." A year later, Congress acquiesced to Webb's lobbying and passed an act to permit the sale of *Dunderberg*, a large and fast ironclad he designed and built under commission during the Civil War for use by the Union. With the war ending before her delivery to the Union cause, Webb sold the vessel to France, where she was re-christened *Rochambeau*.

Higher yield

One of Webb's intellectual contemporaries, the early 19th century French economist Jean-Baptiste Say, defined entrepreneurship broadly as the shifting of "resources out of an area of lower and into an area of higher productivity and greater yield." Having amassed considerable resources, not only in wealth but also in experience, and recognizing the hard economic realities facing American shipbuilding, Webb sold his yard in 1872 and dedicated the remainder of his life to higher yield activities. He was descended from early settlers of the New Haven Colony, and his family had a long reputation for patriotism and civic-mindedness.

Towards the end of his career, and especially after retiring from shipbuilding, he focused on civic and philanthropic pursuits. He donated to deserving causes, helping to feed the destitute in New York and aid those affected by the Chicago fire. He lead the Council of Political Reform in an effort to stifle corruption in New York, and he worked to help secure a safe and reliable public drinking water supply for New York City. He was a patron of the arts, donating to the Metropolitan Museum of Art from its early days, to the American Museum of Natural History, and to the Bronx Zoological Society.

William Webb was an impactful leader who, by virtue of his wisdom and experience, helped to multiply the effectiveness and productivity of many. He was the founding member of SNAME, chartered to advance the collective interests of the maritime community. He served on its executive board until his death in 1899. Some 10 years earlier, in 1889, addressing a need he had identified during his apprenticeship and fulfilling an obligation he felt to those impacted by the collapse of New York shipbuilding, he founded and endowed Webb's Academy and Home for Shipbuilders, known today as Webb Institute. A friend of Webb's at the time remarked that, "As he made a large fortune by shipbuilding and has a small family, Mr. Webb thought the most fitting return he could make to the public would be the establishment of this institution." Webb Institute is responsible for more than 1,500 alumni, who have made countless meaningful contributions to the practice of naval architecture and the interests of the maritime community over the last 125 years.

Paul Graham, one of the most influential and respected venture capitalists today, has said that the hard part of entrepreneurship isn't solving problems, but deciding what problems to solve. William Henry Webb solved the right problems, and he solved them the right way. His lessons in entrepreneurial leadership are many, and he remains a paragon for today's maritime professionals nearly 120 years after his death. **MT**

Brian Petersen *is a 2007 alumnus of Webb Institute and the co-founder and chief scientist of Podimetrics, a revenue-stage medical device company providing preventative technologies and services for patients with diabetic foot ulcers.*



The annual SNAME Maritime Convention features numerous continuing education sessions.

A Primary Mission

SNAME's continuing education and professional development

BY W.L. HURLEY, JR.

Technology in our marine industry is advancing at an ever-accelerating pace. New, multidisciplinary areas of expertise are emerging such as cybersecurity, autonomous vehicles, and hybrid propulsion systems, and controls and automation technology are racing ahead. SNAME members, many of whom are responsible for integrating these new technologies into vessel and platform designs, are challenged to keep up-to-date. To support our members and the industry in general, SNAME works to make available continuing education (CE) and professional development (PD) opportunities.

Support for education is identified in our SNAME bylaws as one of the society's primary missions. While we have a strong focus on pre-professional support in the way of student scholarships, teaching institution accreditation, and liaison with teaching faculty, we also recognize the importance of providing CE and PD to our members throughout their career. SNAME's CE objective is to work with industry, governments, educational institutions, and public education authorities to ensure that engineers in the marine industry have access to adequate programs of continuing education to assist them in advancing and maintaining their professional status.

The first phase of our CE program starts when university or college graduates first enter the marine industry workforce. Support to these members is critical in helping them transition from student to established professional. The second phase is the ongoing continuing education provided to the marine industry professional. SNAME also recognizes the important roles non-engineers and those in related disciplines have in our industry and is considering offerings to increase the breadth and depth of technical knowledge for those members.

Supporting PE registration

In the United States, many of the coastal states require a professional engineering (PE) registration in order to practice naval architecture and marine engineering in the commercial and public sectors, and SNAME supports the pursuit of a PE with three distinct programs.

The first is the PE exam, developed by our Professional Engineering Licensing Committee, which works directly with the National Council of Examiners for Engineering and Surveying (NCEES), which administers and scores the examinations used for engineering and surveying licensure in the U.S. This 8-hour exam in the many engineering aspects of naval architecture and marine engineering has 80 questions and is revised each year.

The second is the PE review course, which is both developed and administered by SNAME, where members can take a series of courses online (including homework) and which culminates in a practice test. The course material is prepared by senior members of SNAME, and this course development is kept separate and independent from the NCEES exam development.

The third program is the PE Continuing Education Credit program, which coordinates, certifies, and distributes credits for all qualified SNAME events. This helps members with PEs to retain them by meeting the CE requirements imposed in some states.

SNAME realizes that the PE program serves a limited segment of its membership, and is working to expand these kinds of career-transition educational opportunities to the non-U.S. membership. However, we also must recognize that, as evidenced by the PE-CE credit program, there is high educational value in all the papers and presentations made at the various SNAME meetings and functions. Members and non-members alike, driven by SNAME's core value of knowledge sharing and dissemination, continually present information on the latest technology and design developments.

Courses, seminars, and forums

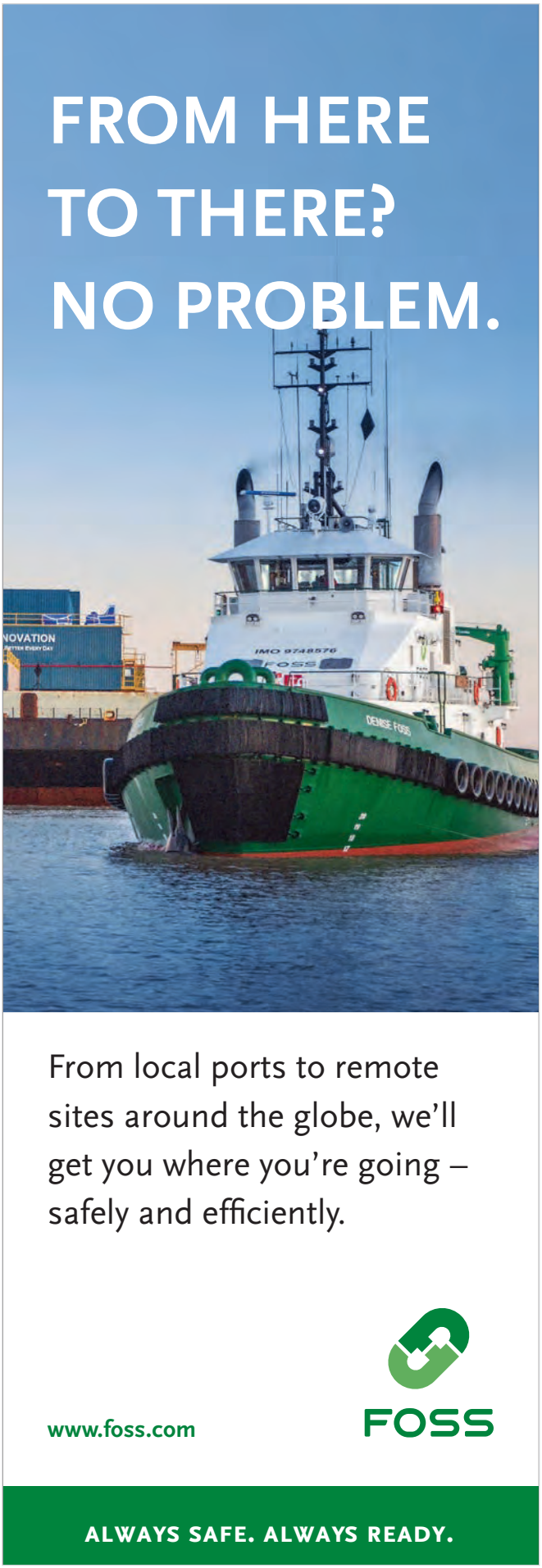
The course program at the annual SNAME Maritime Convention is an important part of the SNAME CE effort. Courses are offered every year and in recent years such topics as wind-assisted commercial vessels, yacht design, and advanced marine vehicles have been taught.

SNAME also has been instrumental in organizing panels and papers at other conferences and symposia as well. This year, at the International Boatbuilders Exhibition and Conference in Tampa, SNAME has organized a "super-session" course on small craft structure. In 2019, at the Offshore Technology Conference in Houston, in collaboration with ASME, SNAME will organize an Offshore Renewable Energy panel session.

In addition, SNAME recently has expanded the use of webinars to provide presentation content in live Web-based videoconferences. Video presentations also are being captured and stored in a Webinar library, accessible to all members, where presentations can be downloaded and replayed at the viewer's discretion.

SNAME recognizes the importance of continuing education and professional development, and the society plans to increase this activity in support of its members. **MT**

W.L. Hurley, Jr. *is chair of the SNAME Education Committee.*





The Microsoft HoloLens is an excellent example of an MRC application that can improve performance and training within shipyards.

Reality Revisited

The mixed reality continuum is helping reduce knowledge and skills gaps

BY MAURISSA D'ANGELO AND GURWINDER SINGH

Editor's Note: *Our July 2017 issue included an article entitled, "Alternate Realities," written by Maurissa D'Angelo and focused on applying virtual, augmented, and mixed reality solutions to maintenance and repair. For this issue focused on education and workforce development, we asked Maurissa to follow up by sharing with us the application of mixed realities to workforce development and training.*

Virtual reality (VR), augmented reality (AR), and the mixed reality continuum (MRC) in between VR and AR provide the shipbuilding industry with an opportunity to revolutionize training, operations, and knowledge capture within the shipyard. VR involves using computer technology to create immersive simulated environments (for example, the user can be in an office location but fully immersed within a shipboard environment using a headset or screen-based system). AR involves enhancing versions of reality where users are still aware of their current physical environment but receive enhancements to the world around them. MR involves blending the physical world and the digital, computer-simulated world. In this case, the physical and simulated worlds are blended into one environment.

The skills gap between incoming workers and those nearing retirement is growing across many industries. The incoming workforce has significantly less exposure to the hands-on skills necessary to perform maintenance jobs and has significantly more exposure to digital and interactive technology such as MRC devices (as compared to previous generations). The MRC presents the education and workforce development community with the capability to quickly and efficiently reduce the gaps in knowledge and skills through providing enhanced training capabilities in

a simulated real-world setting, or through augmenting the real world with enhanced instruction and guidance. MRC components can be used not only to train the incoming workforce and provide refreshers and new training to the experienced workforce, but also to preserve the tribal knowledge of the experienced workforce. MRC applications are not only effective for training, knowledge capture, design, and operations but are also cost-effective when it comes to hardware and software implementation.

Due to advancements in hardware, miniaturization of electronic components, and reduced cost of sensors and electronics over the last decade—especially with the development of powerful mobile technologies (smartphones, tablets, handheld game consoles)—MRC experiences can be integrated with low-cost commercial off-the-shelf devices. The market for MRC experiences also is growing significantly and providing dedicated MRC hardware and software.

Widely accessible

Hardware devices that have been released or are under development have emerged along with supporting software packages that make MRC development and use widely accessible. MRC systems are no longer the exclusive domain of academics or research and development labs. Large companies have embraced the MRC and have developed in-house capabilities or acquired other companies on the leading edge of AR and VR hardware and software (for example, Apple has acquired at least 3 AR/VR/MR related firms in the last year). The MRC presents great potential for improving performance and training across many industries.

> *MRC systems are no longer the exclusive domain of academics or research and development labs.*

AR, VR, and MR are especially useful for design (product design and customization), operations (specific artifacts, installations, processes, or simulations), and education (learning and workforce development). Over time, as more MRC applications become available, especially on mobile devices, the workforce will continue to be increasingly comfortable with the conventions of the MRC. MR and AR are expected to leapfrog VR, because current smartphones and tablets



Reality Revisited *continued*

have enough hardware capability to act as mobile AR/MR platforms by combining the camera, sensor, and graphic capabilities of the device. Many users also prefer augmenting their current environment rather than occluding their environment and being placed in a completely simulated environment.

Following is an exploration of MRC design and operations development that have been implemented in shipyards.

The Shipyard Mobile Applications in Real Time (SMART) effort (NSRP Research Announcement 2018-2019) will provide a turnkey mobile application solution configured for shipyard point-of-use data collection and high velocity exchange of location-aware quality, schedule, and technical information. This project will integrate MR technologies to enable shipbuilders to access relevant and current information based on visual awareness of ship location and to capture and report technical information digitally in real time. This will provide a total integrated system solution for shipyard workers and enable mobile applications to be accessed through AR location-aware capabilities. It will give the shipyard worker technical information in an easy-to-use database and enhance overall operations. A unique aspect of this effort is that the integration of the MR software platforms will be independent of hardware selection so that the life of the applications can accommodate upgrades to new hardware technologies.

The Improving Workforce Development Initiatives Using Augmented Reality Technology (NSRP Research Announcement, 2017-2019) project will explore the use of instructional AR technology during formal instructor-led training, as well as the potential for use in informal, continuous, and on-the-job training in a shipyard environment. The goal of this effort is to determine areas where AR technology can benefit the performance of shipyard activities through an increase in productivity and a reduction in costs associated with various training courses. AR serves to reduce inefficiencies and classroom training time, replaces costly mockups/graphics-based scenarios, and helps to improve and support job performance on the deckplate. This effort demonstrates that AR can benefit users by providing easy and quick access to 3D visualizations of equipment that overlays part identification data, step-by-step work instructions, and safety information.

A Virtual Reality Crane Simulator was installed for use in shipyard training (2017). This overhead crane was custom made for use as an effective and safe training tool. The simulator provides users with an immersive and safe environment in which to train on proper crane operation without the risk of costly mistakes using a real crane system. New users can practice and learn from many different scenarios that an instructor can input, while more experienced users can practice specific operations before tackling the same operation with real production cranes.

The ARgos project (NSRP Research Announcement, 2016-2018) involves the development of a framework for knowledge capture, knowledge transfer, design-build integration optimization, and improving the specific shipbuilding issue of difficulty in accurately and efficiently identifying specific cable hangers within the ship or submarine under construction.

The VR side of ARgos captures knowledge from skilled cable installers and transfers the captured knowledge to new workers. Using VR enables better understanding of the situation aboard the ship worksite and enables trial/training of assembly tasks due to the 1:1 scale and interaction capabilities. This combination of immersion and interaction aids in reducing errors during assembly, reducing required working time, and helping to produce higher quality work due to better understanding via this training. The VR environment gives visual feedback similar to the real world, which is further enhanced by physical feedback in the form of vibration on the hand interaction devices and handling of real-world physical cable segments tracked to the virtual model.

The AR portion highlights enhanced operational capabilities. As the cable installers move through the interior of the ship or submarine with their mobile AR display, the AR device provides on-screen identification of cable hangers in the view of the display's forward-looking camera. Computer generated annotations and indications are overlaid on the installer's display to direct the user to the correct location within the physical space for cable installation. This entire process must be

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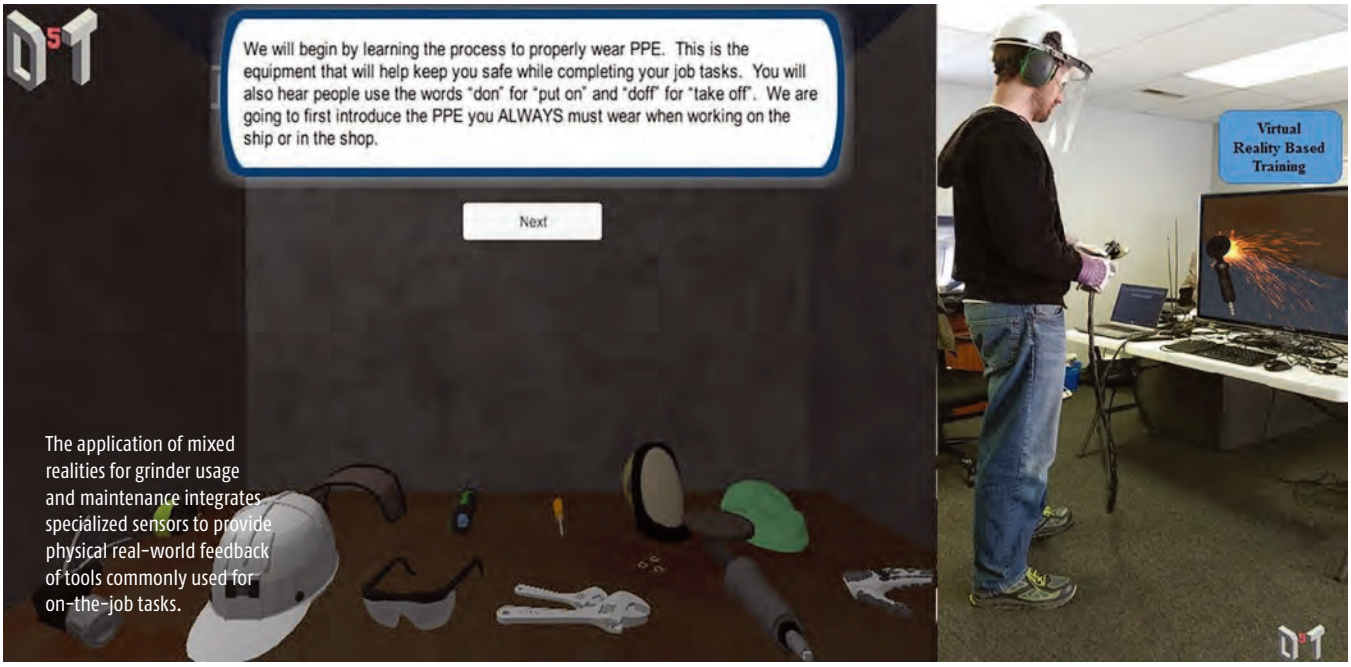
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usmma.edu/after-graduation/graduate-program

or you may contact the MMarE Program Director:

Dr. William Caliendo, P.E.
Tel: 516-726-5722
Email: caliendow@usmma.edu



The application of mixed realities for grinder usage and maintenance integrates specialized sensors to provide physical real-world feedback of tools commonly used for on-the-job tasks.

accomplished in near-real time to maximize the productivity of the cable installation team.

spARky (NSRP Research Announcement, 2015-2016) used AR technology to capture installation of wiring connections. The goal of spARky was to replace 2D schematics with more cost-effective 3D models. Integrating AR and 3D models can result in electrical installations presented as advanced 3D visualization aids that can be delivered to users through digital tablets. These visualizations will help users through the installation process by showing the exact positioning of connections rather than reading from a paper schematic. Because the 3D wire models are made from the 2D schematics and wire tables, any shipyard will have the ability to use this process to help increase installation efficiency and reduce costs.

The Use of Mobile Robotics to Increase Welder Productivity and Weld Quality (NSRP Panel Project Effort, 2015) project used a mobile welding robot modified from the VirtualWelder virtual reality welder training system to increase the productivity and weld quality in shipyard environments. The robot is controlled by a skilled welder through a virtual cell, where the welder holds a controller that is the size, shape, and weight of a real welding torch. Every movement the welder makes with the controller is mimicked by the robotic welding torch. A video feed is streamed to the welder in real time, so they can see and control the robot as it welds. The robotic welder was designed with magnetic crawler treads, so it can operate on most steel structures with flat, vertical, and overhead orientations. This process has been shown to decrease welding time by two to four times what a manual welder can do and enables subject matter experts to operate the robotic welding machine.

The Virtual Reality Training project (NSRP Research Announcement, 2014-2015) goal was to develop a virtual shipyard



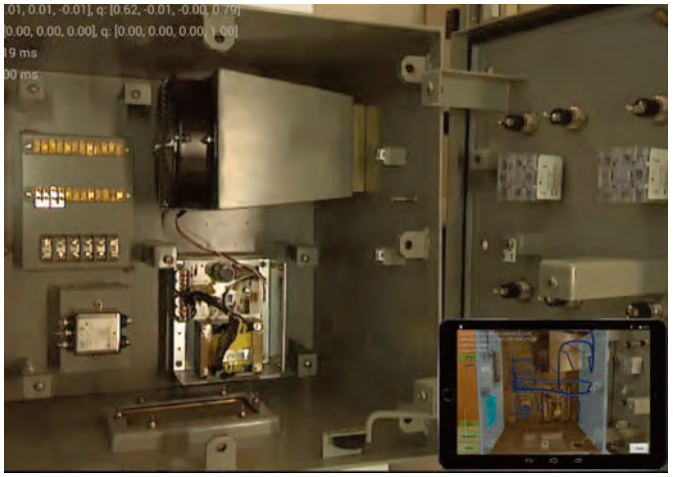
Integrating virtual reality tools demonstrates the capability to provide visual feedback and instruction for wire terminations, all within the safe environment of an office or classroom.

environment that supplied an immersive training module for users of any skill level with a focus on new hires. This environment provided a variety of training information and scenarios including use of personal protective equipment (PPE), grinder usage, and grinder maintenance. Subject matter expert knowledge was captured and integrated into the comprehensive hands-on MR modules. Each module trained the user on steps required for proper handling of equipment and proper use of PPE. The modules developed can be implemented across the shipbuilding industry to help reduce training time, reduce rework due to improper equipment usage, and increase advanced and refresher training availability.

Reality Revisited *continued*



The mixed reality continuum demonstrates the capability to alter physical reality, develop a completely immersive simulated reality, and create a mixed reality scenario that integrates both physical reality and enhanced digital reality overlays.



Using an AR device (tablet) provides visual feedback and instruction for work instructions in order to provide electrical installers with advanced 3D visualization aids to effectively, efficiently, and accurately complete their tasks.

This effort enabled a small business (virtual reality training developer and integrator) to enhance training capabilities at a large shipyard. Although this effort only lasted one year, three interactive and immersive modules were developed for shipyard use (grinder maintenance and usage and PPE usage). The effort demonstrated the feasibility of integrating MR for training as well as integrating tooling and tool usage (hands-on applications) into the MR environment. The prototypes were tested by the shipbuilding community (including NAVSEA) and received favorable reviews. Many of the users stated that they would like to see additional modules for various equipment training for both new users and for refresher training.

Virtual Reality Wiring Training (NSRP Panel Project, 2012) provided a proof of concept demonstration to validate feasibility of a VR training module to supply installation and training inspection references. Wiring systems are typically treated as a fit and forget commodity until failure occurs. This project was developed as there was no training manual tailored for proper shipboard wiring techniques in shipbuilding for new installation, preventative maintenance, and unscheduled maintenance. It also was documented that there was no formalized inspection training to verify optimal wire installation and maintenance procedures. An interactive and integrated VR training test module was developed to provide the shipbuilding community with baseline resources for efficient training and skilled maintainers. The team verified the feasibility of developing and integrating a VR training module for installation training and an inspection environment. This virtual environment enabled users to practice on a virtual ship and visualize proper installation procedures. The final deliverable to the shipbuilding community was a video demonstration of the training module for feedback and assessment and ultimately raised awareness of the benefits of VR integration in shipyards.

The Shipbuilding Orientation Program, a virtual shipyard effort (NSRP Panel Project Effort, 2011), resulted in the development of a virtual shipyard orientation course targeted at individuals who are new to the shipbuilding environment. In this course, users can travel through a 3D shipyard environment and learn about the different aspects of shipyards and the shipbuilding process. The trainee can follow the material handling pathway from receiving through production to its final destination on the ship. The course provides information about shipyard processes, materials, and safety. This information is presented through an interactive format to engage users, but also to enable them to participate in interactive training scenarios, repeat efforts as necessary, and train at their own pace. The initial course was designed to be generic for a general shipyard overview. The courses can be customized to specific shipyards and specific specifications for a more individualized and shipyard specific learning experience.

The Low-Cost Virtual Reality Welder Training System project (NSRP Research Announcement, 2008-2011) developed a new and

more affordable virtual welding training system. This system enabled users to learn various weld styles and positionings through virtual visualization and auditory responses. Users received immediate feedback during training. During phase I, a prototype was developed for a proof of concept. This prototype integrated low-resolution video goggles as a display, the consumer gaming commercial off-the-shelf Wii remote device for tracking, and a virtual environment made with an ArcSentry system (modified to display the welding process, torch, arc, and weld bead). Phase I demonstrated the proof of concept and capability to simulate basic welding processes using low-cost equipment. Phase II focused on refining the prototype design into a fully functional and robust system. The Wii remote tracking was replaced with OptiTrack camera tracking bars to enhance calibration stability.

This effort integrated shipyards (tier 1 and tier 2) with a virtual reality integration small business. Additionally, a university aided in the development of a welding helmet. As part of their senior capstone project, students upgraded the low-resolution goggles to a welding helmet that used an inward-facing liquid crystal display screen. The hardware upgrades were integrated through new system software that was used in integrating real welding experimental data into feedback for weld creation during training. The final product is a system that enables users to make welds receive real time feedback, and to evaluate the quality of the welds while also tracking improvements as training progresses.

Other industries

Boeing has announced a plan to test AR in their factories. Currently, installing electrical wiring for an aircraft requires the technician to interpret and construct a mental two-dimensional object and, based on this mental construct, complete the task accurately. This unstructured approach greatly increases the potential for errors in a discipline where errors must necessarily be eliminated. AR can help with this by overlaying instructions and schematics within the users surrounding, thereby enhancing the chances of successful task completion. Paul Davies, Boeing Research & Technology associate technical fellow, claims that theory studies have shown a 90% increase in first-time quality and 30% reduction in time with the use of AR over traditional methods (looking at the 2D drawings).

In 2015, Amnesty International UK, a non-governmental organization focused on human rights, used VR for fundraising. Amnesty launched a campaign called "Virtual Reality Aleppo" to inform people in Britain about the devastation happening in Aleppo, Syria. Amnesty trialed eight VR headsets to highlight the war-torn streets of Aleppo and plans on implementing more headsets for the future. The fundraisers reported many more people spoke to them in order to experience the VR scenes and that the VR images resulted in a more powerful emotional response from users. Amnesty International also reported a 16% increase in sign-ups for direct debit donations.

In 2015, the University of California, Los Angeles Department of Neurosurgery collaborated with Surgical Theater LLC to integrate Oculus Rift with Surgical Theater's surgical navigation advanced platform (SNAP) to generate "virtual brain(s)." This enables neurosurgeons to take patient specific CT and MRI scans and "walk inside" the patients brain. The claim is that this will improve precision and surgical outcomes while decreasing the time of surgery. Research conducted at Stanford University found that when it comes to VR, the brain absorbed spatial details 33% more effectively when compared to video. Therefore, the Oculus Surgical Theater affords the surgeons the ability to come up with a plan of attack for the best method of treatment for the patient.

These figures are promising. MRC enables improved design, operations, training, and knowledge capture capabilities using state-of-the-art technology and software applications specifically developed to enhance task-based understanding. MRC applications are increasing and the technology costs for implementation are falling. These technology applications will enable the United States shipbuilding community to continue to support a state-of-the-art, elite United States Navy. Although market growth can be difficult to project and depends heavily on assumptions, there are predictions that the MRC markets will grow by tens of billions of dollars by 2020. In fact, Markets and Markets predict an AR market of approximately $61.39 billion by 2023. **MT**

Maurissa D'Angelo *is president, and Gurwinder Singh is integration engineer, at D'Angelo Technologies, LLC in Beavercreek, OH.*

Deeper Dive

For more information on the technologies and projects examined in this article, check out the following online resources.

"AGCO pioneers the use of Assisted Reality in manufacturing at U.S. factory." Available at https://news.agcocorp.com/topics/agco-innovations-in-manufacturing-with-glass

"First use of virtual reality fundraising a hit with members of the public." Available at https://www.amnesty.org.uk/press-releases/first-use-virtual-reality-fundraising-hit-members-public

"Boeing: Boeing Tests Augmented Reality in the Factory." Available at https://www.boeing.com/features/2018/01/augmented-reality-01-18.page

"UCLA Neurosurgeons Are Stepping Inside Their Patients' Brains Using Oculus Rift, 3D Virtual Reality Gaming Technology with Surgical Theater's 3D Surgery Navigation Device." Available at https://www.businesswire.com/news/home/20150501005609/en/UCLA-Neurosurgeons-Stepping-Patients%E2%80%99-Brains-Oculus-Rift

"Augmented/Virtual Reality to hit $150 billion disrupting mobile by 2020 | Digi Capital." Available at http://www.digi-capital.com/news/2015/04/augmentedvirtual-reality-to-hit-150-billion-disrupting-mobile-by-2020/#.V5J2eLgrLIW

"Augmented Reality Market by Offering Device Type (Head-Mounted, Head-Up and Handheld) - 2023 | MarketsandMarkets." Available at http://www.marketsandmarkets.com/Market-Reports/augmented-reality-market-82758548.html



A gathering of young professionals at the 2016 SNAME Maritime Conference in Seattle, WA.

Transcending Networking

SNAME's Young Professionals program is changing the dialogue

BY NATHAN HAGAN

Membership is the one of the greatest values offered by a professional society. This relatively simple concept transcends access to technical content or professional networking. Membership is about belonging. As a young professional, the world can be intimidating. You have just finished one of the most challenging periods of your life, during which you likely got little sleep and faced a fire hose of information. You did all of this for the privilege of an incredible education, the stresses of student loans, and the possibility of a good job that will remove that burden of debt. It is an exciting time, full of optimism and dreams. However, it also is an incredibly lonely time, in which, possibly for the first time in your life, you are legitimately alone. No longer will you live in dormitories with your closest friends, nor will your work be graded objectively on a scale of pass or fail.

Like many other people, this was my story after graduation. I had just started a wonderful job working at the Naval Surface Warfare Center, Carderock Division, in Bethesda, MD. I found myself in a new place lacking the clear direction that was laid out during the process of an academic career with distinct milestones leading to an eventual graduation.

Fortunately, I was a member of SNAME. I was engaged as a college student in my local section and globally through the Student Steering Committee. I attended local section meetings regularly in the New York Met section, and experienced the simple pleasure of mixing social and professional aspects of my life through the society. While my SNAME involvement as a student gave me some confidence in my choice of career due to technical familiarity with the industry, it didn't explicitly make the move easy.

I did the "networking" thing at the SNAME Maritime Convention in attempts to find employment. Gradually I changed my objective from employment to building relationships with mentors and peers across the society. Eventually I was able to identify a community of individuals at my future employer as well as make connections with the Chesapeake section of SNAME, of which I would soon be a member. When I was at this stage of my life, SNAME had just started the Young Professionals program under the guidance and leadership of Matthew Unger. Through this program, each local section added an appointed officer, a Young Professionals coordinator, whose role it was to engage with young professional members within the section and plan social and professional activities that served the needs of that demographic. Upon graduation, the chair of the Chesapeake section asked if I would serve in this role. I happily agreed.

First-hand experience

It didn't take long for me to realize that coordinating activities was hard, though that was mostly due to my

You have just finished one of the most challenging periods of your life, during which you likely got little sleep and faced a fire hose of information.

tendencies as an introvert and my lack of experience in addressing the questions that I, too, was having professionally. I understood first-hand the issues facing young professionals, but on my own it felt like I didn't have the resources to address them, let alone to offer those resources to others in need. This stress was magnified by the Young Professionals program being relatively new.

Fortunately, I was not alone. SNAME offered the organization of membership of other professionals who had similar experiences—both older members who were able to reflect on the beginnings of their careers and fellow young professionals, both in coordinator positions at other sections and those who were simply active members.

The network of online resources offered by SNAME both supported my role as a Young Professionals coordinator to perform those duties and enabled me to address my own needs as recipient of those benefits professionally. The community of Young Professionals members reminded me that I was not alone in my experiences, and more importantly that I did not need to face them alone. My career was not a test in a classroom, where talking to your classmates would be considered cheating. It was a group project, in which you could choose your teammates dynamically, and rely on the strengths of all those around you to overcome the challenges that you face.

During the time that I served as a Young Professionals coordinator for the Chesapeake section, the community grew, and we established an effective global committee that went on to organize a new professional development seminar for the SNAME Maritime Convention. It was a great way to work together with peers around the world on an event aimed directly at addressing the needs of the professional concerns of people like us. In the first year of the seminar, we held a panel discussion with industry leaders on their prior experiences and offered development workshops on negotiation. Later seminars would include topics on networking, résumé development, program management, and participation in SNAME's T&R panel programs.

Presentation styles

The most critical aspect of these programs, however, was not the content. Rather, it was how the content was presented. As young professionals, it became clear that there is a value in acknowledging generational differences between members in SNAME, and to understand clearly how people in difference generations prefer to communicate. Ultimately, I found that the motivations that drive us to pursue our passions in engineering and the maritime industry are very similar across age demographics, but our approaches differ significantly. The Young Professionals seminars presented information in a non-formal environment, which enabled an open exchange of experiences and strengthened the sense of community among all participants, both those providing knowledge and those receiving it.

Ultimately, these programs offered an outlet to participate. Through our activities, socials, and seminars, we started changing the tone of conversation and how young professionals were represented within SNAME. The informality of our approach emphasized the people over the content. As young professionals, we were valid. Our perspectives on life were relevant. Our humor. Our anxiety. Our optimism. For myself, this was exemplified by the introduction of the



Transcending Networking *continued*

> *As young professionals, our culture is SNAME culture. Who's to say a SNAME presentation of the future can't be full of humor and memes?*

Francis T. Bowles Medal in 2017, recognizing "notable early career achievement by a young maritime or ocean professional." The inaugural award, which was presented to Matthew Unger, was just the start of SNAME's public acknowledgement of the contributions and potential of this under-represented community within our industry. I'd like to emphasize that this wasn't just a certificate of participation. It is a paradigm shift in the long-standing idea that our societies' highest levels of recognition should be limited only to lifetime achievement awards.

For me, the existence of programs and opportunities for recognition like this, and the supplementary tangible skills, both technical and professional, that these activities have provided was all it took to encourage me to confidently develop my career path and pursue leadership positions within my organization. With the negotiation methods developed in Young Professionals seminars, I was able to develop and gain support for a research project within the navy that focused on structural design tools. I managed the program for more than a year before transitioning to a larger role as a technical advisor for data analytics and systems engineering implementing digital strategy for the executive director of the NAVSEA Warfare Centers.

Applying experiences

I have taken the experiences gained from the Young Professionals program at SNAME and applied them to every aspect of my professional career. I re-established a New Hire Bridge employee resource group at Carderock, a sort of Young Professionals organization for the command. This community has proved to be a great resource to bring people together on base, while also offering a social outlet to advocate for the roles of professional society membership for navy employees.

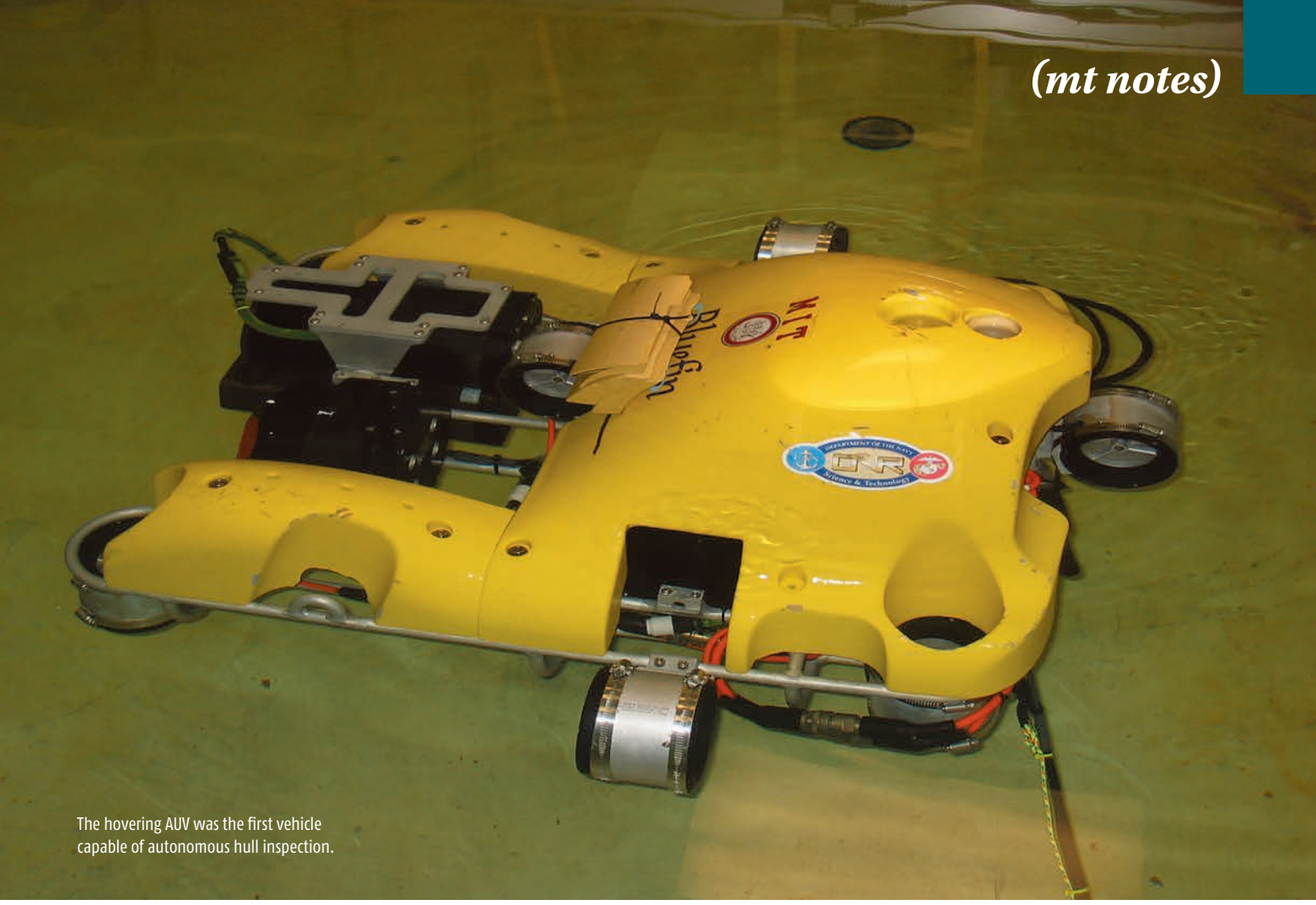
It is easy to see how the Young Professionals program at SNAME has impacted my career as a maritime professional. The program enables me to shape the industry first-hand with like-minded technical professionals across the globe. However, the true value is in belonging to something bigger—the membership in the society and the commitment of the organization to recognize, inspire, and offer a voice at the table for my generation of ocean and maritime professionals. I have established friendships rather than simply a professional network and I have helped change a dialogue for the areas of focus at the forefront of the industry's radar. And perhaps even better, my advocacy in these fields across SNAME has led to my leadership positions in these disciplines in my professional career as well.



The author models the latest in SNAME-approved headgear.

I am proud to call myself a SNAME member and even more proud to call myself a young professional, a member of this active, passionate, and growing community. I hope this is a call to action for you. While the Young Professionals program has done a lot in less than 10 years, there is still so much more we can do. Without us, the society will die. As young professionals, our culture is SNAME culture. Who's to say a SNAME presentation of the future can't be full of humor and memes? Let's share with the world all of the things that make us so passionate about this industry that we choose to call our own. I hope you join me as a member and that you join the conversation and let your voice be heard. **MT**

Nathan Hagan *is a naval architect at the Naval Surface Warfare Center, Carderock Division.*



The hovering AUV was the first vehicle capable of autonomous hull inspection.

Research, Outreach, and Education

Benefitting Massachusetts and the nation

BY MICHAEL TRIANTAFYLLOU AND CHRYSSOSTOMOS CHRYSSOSTOMIDIS

The MIT Sea Grant Program is part of a network of 33 regional University-based Sea Grant programs. The national program was established by Congress in 1966 with the unique structure of a collaborative program between the federal government and universities in coastal and Great Lakes states, to provide research and education to state and local coastal entities. Its annual nationwide budget of $73 million leverages significantly more funds from other sources, as 50% matching non-federal funds is required for each project. The matching funds requirement guarantees commitment, dedication, and participation from project leaders, institutions, and users of its end products. A vision is set through strategic planning meetings involving constituents and an advisory committee, with the purpose of agreeing that the program's vision will result in meaningful contributions to ocean sciences and best serve coastal communities.

MIT Sea Grant funds a rigorous research program, dedicated outreach programs, and integrated educational projects aimed at providing real-world solutions to coastal questions and at helping to create the coastal stewards of tomorrow. MIT Sea Grant funds marine research through an annual funding competition open to Massachusetts university-based researchers. Currently, our in-house research includes the work of the Autonomous Underwater Vehicle (AUV) Lab, and the Design Lab for Naval Architecture and Marine Systems. The MIT Sea Grant Marine Advisory Services group conducts applied research in coastal habitats, marine bio-invasions, water quality, climate change, fishing communities and policy, and offers hands-on marine science education programs.

Our mission at Sea Grant is to conduct and support research, and to develop technology, to enable scientific investigation into problems surrounding the ecosystem health and human use of coastal and marine environments.

Research, Outreach, and Education *continued*



Members of the Sea Grant AUV Lab use the Odyssey vehicle in the Arctic.

The education and outreach efforts disseminate the results of our MIT Sea Grant-funded research, and research conducted by our AUV lab and advisory staff in collaboration with industry, state, and federal partners. These stakeholder engagement, education, and outreach efforts are meant to encourage stewardship and implementation of sustainable and useful technologies that help answer management questions in support of public policy and industry through the use of relevant, evidence-based, and scientifically sound information.

Efforts in research, education, and outreach are designed to address critical marine and coastal issues at the state, regional, national, and global levels that have been identified by Massachusetts constituents and which are within the areas of focus for the National Sea Grant College Program. The goals of the focus areas shape priorities for our annual solicitation to fund new proposals, and they guide us in both the short and long term toward projects whose success can best serve our constituents. An advisory committee reviews the program to be in agreement with our mission and goals, as the general focus areas evolve over the years. For example, our current focus is on ocean acidification, sensor and platform development, modeling and analytics, forecasting, and fisheries and offshore aquaculture research and engineering. As always, we take to heart the stated vision, but in order to implement it we always try to expand our horizons through multi-disciplinary efforts. Recent and current research efforts include big data and deep-learning methods to develop monitoring and predictive capabilities for ocean acidification; multi-fidelity machine learning methods to design novel autonomous platforms and ships for ocean exploration and characterization; and novel technology for data transmission in the ocean.

Marine technology

Research efforts have produced new tools, instruments, and pioneering technologies. Following are examples of these efforts.

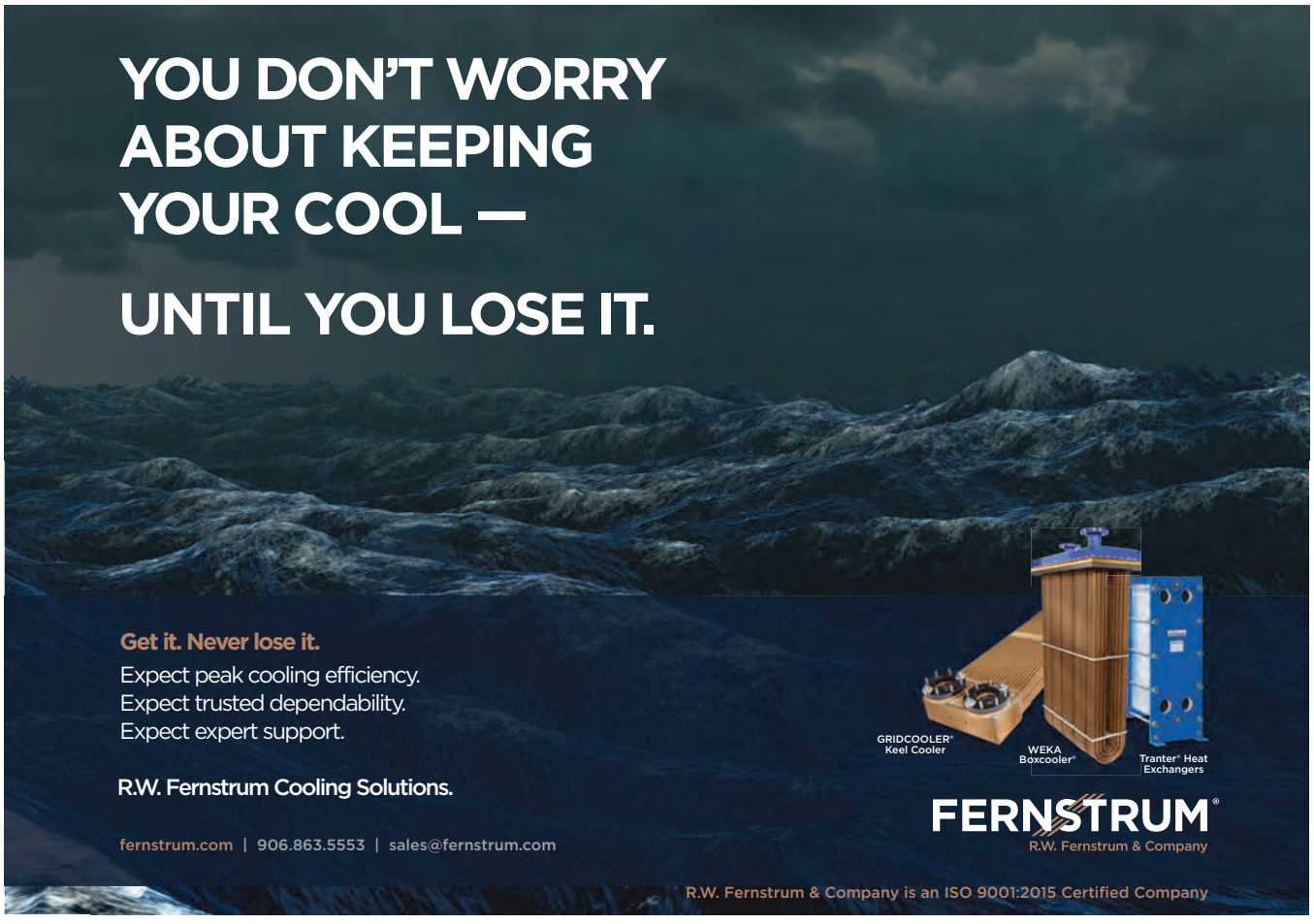
Odyssey vehicles. The Autonomous Underwater Vehicles Laboratory, established in 1988 by co-author Chrys Chryssostomidis at the MIT Sea Grant Program, has pioneered the development of autonomous exploration vehicles worldwide using seed funding from Sea Grant and funding from federal and non-federal sources. Among several successful vehicles designed and launched by Jim Bellingham, Jim Bales, John Leonard, and Tom Consi, the Odyssey AUV has been involved in numerous missions worldwide. The Odyssey vehicle proved for the first time that a vehicle 1 to 2 meters long, weighing less than 200 kg so it could be hand-carried in the field by a few engineers, could perform successful missions exploring the ocean at reasonable capital and operational cost. Marc van Mierlo, a member of the AUV lab, was instrumental in commercializing the vehicles through the spinoff BlueFin Robotics, creating one of the leading AUVs nationally and internationally. It has been used for numerous oceanographic, archaeological, and naval applications.

The laboratory robot RoboTuna was instrumental in developing the principles of unsteady propulsion as employed by aquatic animals.

Inspection autonomous vehicle. With initial funding by Sea Grant, Franz Hover developed the hovering autonomous underwater vehicle (HAUV), which can inspect complex marine structures completely autonomously. This was typically performed by human divers, equipped with sonar cameras, to inspect the condition of hulls and to search, for example, for underwater mines attached to ship hulls. The United States navy also has trained dolphins and sea lions to search for bombs on and around vessels. While animals can cover a large area in a short amount of time, they are costly to train and care for, and don't always perform as expected. Franz Hover developed the vehicle and algorithms to perform the complex task of viewing a massive structure such as a naval combat vessel, as well as all its small features, including bolts, struts, and any small mines. The technology has since been commercialized by the spinoff Bluefin Robotics Corporation.

Research and industry growth. MIT Sea Grant has a long history of investing in research that leads to industry growth, such as the BlueFin Robotics. Whether it is funding cutting-edge research that stimulates job growth and businesses development, or providing learning and advancement opportunities for students and talented early career professionals, MIT Sea Grant has made an impact on the marine technology industry, leading also to applications in other fields. For example, 10 years ago MIT Sea Grant funded research in the development of an ocean sensor that evolved into a successful company, Lantos Technology.

Marine biomimetic technology. With initial funding from Sea Grant and funding from DARPA and ONR, the laboratory robot RoboTuna was instrumental in developing



Research, Outreach, and Education *continued*

the principles of unsteady propulsion as employed by aquatic animals. Biomimetics has developed as a major discipline since then and has led to a series of aquatic and aerial robots and sensors developed at MIT and in many institutions and industries worldwide. The original RoboTuna is currently on exhibit in the Museum of Science London and in the MIT Museum.

Education

MIT Sea Grant is helping to meet the state and national need for quality science, technology, engineering, and math (STEM) education in addition to increased ocean literacy. A suite of hands-on educational programs in marine ecology, ocean engineering, and underwater robotics offer learning experiences for young people in support of STEM principles. MIT Sea Grant's formal and informal education programs for students, professional development opportunities for K-12 teachers, and published educational materials aim at reaching broad audiences. These programs are often produced and distributed in collaboration with partners. Signature programs include the SeaPerch underwater robotics program, the summer Ocean Engineering Experience (OEX), the statewide high school ocean science Blue Lobster Bowl competition, and various internship opportunities.

With SeaPerch, the scientific community deemed that the best way to reach the young population in STEM is through a hands-on project that is easy to execute and inexpensive. The MIT Sea Grant program was inspired by the book, *Build Your Own Under Water Robot and Other Wet Projects*, by Harry Bohm and Vickie Jensen, and created the SeaPerch, a very successful education project that has reached many students in the U.S. and abroad (France, Italy, Greece, Cyprus, and Thailand). The SeaPerch is a remotely-operated vehicle that students can build and operate themselves. Through teacher training and by partnering with a nonprofit, SeaPerch is used in K-12 classrooms across the country. More than 400 programs across the country use SeaPerch as a tool to teach ocean engineering, and more than 100,000 children and adults have been introduced to SeaPerch at informal education events. MIT Sea Grant educators also use SeaPerch in an intensive engineering high school summer camp for women and minorities.



Dr. Jim Bellingham of the Sea Grant AUV Lab with Odyssey 1.

Outreach

The MIT Sea Grant Program is working to help communities adapt to negative impacts on coastal ecology, waterfront properties and infrastructure, and the fishing industry by providing information, advice, and on-the-ground and in-the-sea research. Examples include the "Climate Change Tools and Resources" guide, workshops on communicating climate change, and surveys of salt marshes on the south coast to study habitat quality and vulnerability to sea level rise.

The communications staff at MIT Sea Grant ensures that research findings and outreach programs reach the broadest possible audience. Fellow scientists and engineers, stakeholders, and the general public are apprised of MIT Sea Grant research and activities through digital and print media, technology demonstrations, research seminars, and other outreach events. An attractive and content-rich Web site, an e-newsletter, printed materials, and scholarly publications are some of the vehicles used to convey MIT Sea Grant news and programs to the world. Other strategies for bringing new audiences to our work include art installations, online videos featuring exciting projects, and educational activities.

With the annual River Herring Citizen Science and Outreach program, MIT Sea Grant fisheries biologists coordinate three citizen science programs, annually training 150 participants in river herring ecology, monitoring and assessment methodologies, fisheries management, and the historic importance of river herring to local communities. The program also includes coordination of 12 public outreach programs that focus on enhancing the awareness and understanding of river herring ecology, the importance of the species to local communities, and fisheries habitat restoration. These outreach programs have targeted the general public, reaching some 1,200 participants annually. Program partners have included NOAA Fisheries Service; Massachusetts Division of Marine Fisheries; Massachusetts Division of Fisheries and Wildlife; Massachusetts Division of Ecological Restoration; The Association to Preserve Cape Cod; the MassBays National Estuary Program; the Massachusetts

Audubon Society; and the towns of Plymouth, Orleans, and Eastham, MA.

The MIT Sea Grant Fisheries Emergency Response manual was begun in 2016 as MIT Sea Grant was the first to recognize the importance of social science and the human dimension aspects of coastal and ocean science and policy, and was the first Sea Grant program to add an anthropologist to its Marine Advisory Services group. The Responding to Emergencies at Sea and to Communities Under Extreme Stress (RESCUES) manual developed by MIT Sea Grant contains step-by-step guidance that will help prepare individuals, groups, and communities for crises affecting members of the commercial fishing industry. The project partners included NOAA Fisheries; Harvard University School of Public Health; the New Bedford Fishing Heritage Center; the United States Coast Guard; fishing community leaders in MA, NH, ME, and RI; the Fishing Partnership Support Services; and the NOAA Northeast Fisheries Science Center.

Additionally, with the MIT Sea Grant Data Systems Development Program, MIT Sea Grant has capitalized on its facility to develop enhanced technologies in support of resource management and coastal communities. The MIT Sea Grant Data Visualization and Analysis System was first developed for the town of Nantucket to support its coastal water quality monitoring efforts. The cloud-based system enables efficient collection and storage of data, and incorporated customized visualization, mapping, and analysis tools. We are now working with the Massachusetts Division of Marine Fisheries and the MassBays National Estuary Program to develop data monitoring systems to meet their program needs. A second data system, eSeaGrant, was for the National Sea Grant Program Network to manage funded research programs and facilitate overall program reporting to the National Sea Grant Office.

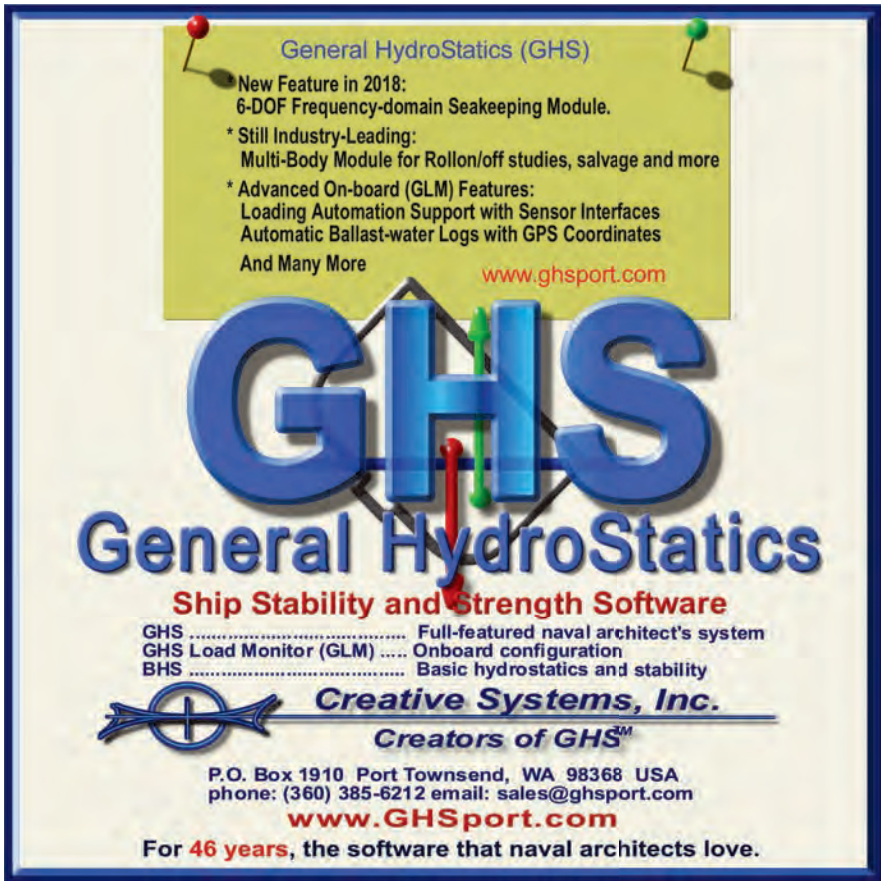
Four focus areas

MIT Sea Grant will continue to develop game-changing technologies and systems to address environmental issues of greatest concern and to achieve the goals of sustaining resources, communities, industry, and economies in the future for Massachusetts and the nation. Four focus areas address the core of the national Sea Grant College Program mission and vision, and these frame our goals and outcomes: healthy coastal ecosystems; sustainable fisheries and aquaculture; resilient communities and economies; and environmental literacy and workforce development. We solicit input from our advisory committee, networking partners, and liaisons with local, state, federal, and regional agencies and organizations, industry, and the general public.

Through MIT stakeholder meetings in 2016, we found that high among constituents' concerns are preserving and restoring coastal resources; promoting environmental stewardship; coastal resilience; wise use and management of coastal resources; fisheries and aquaculture; and water quality. Technologies designed at MIT Sea Grant have led to new business creation and we expect this pattern will continue to create jobs and generate revenue for Massachusetts. Our commitment to education from K-12 to undergraduate, graduate, and adult learning integrates our research in marine and coastal science, engineering, and technologies.

Mentoring undergraduate students and supporting MIT graduate students and post-doctoral fellows involved in cutting-edge research builds capacity for a trained workforce in science and engineering, a recognized need at both the state and national level. Our marine advisory staff conducts research and develops programs and materials that transfer technology and scientific information to industry and decision makers to encourage stewardship as leaders strive to balance growth and sustainability of resources. **MT**

Michael Triantafyllou *is a professor of mechanical and ocean engineering, and* ***Chryssostomos Chryssostomidis*** *is a professor of ocean engineering, at the Massachusetts Institute of technology.*





Webb mentors and mentees gather at Homecoming 2018. From left to right: Kevin Prichard '18; Bryce Bartling '13; Vinnie Commisso '18; Megan Green '18; Vicky Dlugokecki '88; Ian Mutnick '96; and Steve Pagan '88.

Fostering Long-Term Relationships

How do you connect mentors with mentees?

BY SATCHEL DOUGLAS AND SEAN MURPHY

In early 2017, the Alumni Association at Webb Institute started a mentoring program for Webb students in their junior and senior years. The program has two purposes: to help students achieve their personal and professional goals and to strengthen the bonds between members of the Webb community. Students are paired with alumni, who volunteer their time to provide advice, guidance, and sometimes jobs to the students.

Internally known as the Webb Alumni Mentorship program (WAM), the program has made 55 mentor-mentee pairs to date. Participation in the program is offered to students during their junior and senior years when, among the litany of homework, tests, projects, and internships, students begin to seriously consider the reality of life after Webb. Recognizing that, for many, this may not be an easy question to answer, Alumni Association President Peter Wallace came up with the idea for the program: "Mentoring comes naturally to Webbies and we formalized something that existed in bits and pieces. The objective is to encourage long-term relationships between students, recent graduates, alumni, trustees, the college, and the industry." The goal of WAM is not to help students get jobs (though this happens quite frequently). Rather, it's to provide mentors who can expose students to a wider range of possibilities and support their professional and personal growth.

The process of pairing students with alumni mentors and helping them form a relationship continues to evolve. In the first year of the program, students were paired with mentors in the spring of their senior year. Because most students had already made a decision about a post college path, we shifted the pairing earlier. As it stands now, students are asked to complete a six-question survey before beginning their junior year. The survey asks a few straightforward questions about future plans and interest, but also asks students to define their values, describe someone they look up to, and explain how they would survive a zombie apocalypse. Unsurprisingly, a high percentage choose to escape civilization by ship.

Volunteer mentors are asked to complete a more straightforward survey, which asks only for contact information and area of the industry. Initially, we did not ask for detailed information about a mentor's work experience, and spent hours trolling LinkedIn for work history data to fill in the blanks. To remedy this, we now ask mentors to submit their résumé, or a description of their work experience. Finding willing mentors has been one of the easiest parts of the program: 108 alumni have volunteered so far.

Solid pairings

The most labor-intensive part of the process is pairing mentors and mentees. The management of the program and pairings are done by the authors, as members of the Webb Alumni Association Executive Committee. We knew the first two classes of students paired, which made it possible to consider information outside of what was provided in the surveys. When students identify a specific career path or goal, it often is possible to pair them with a mentor in that area. High value is placed on making pairings within the same industry sector, but often students do not have a specific field in which they are interested. In this case, we look at their responses to the ancillary questions for a hint. Because we know many of the alumni mentors

personally, we can sometimes make a pairing based on a shared data point.

We may also pair the unsure students with alumni who have made a significant career change or have experience across different sectors, the theory being that those alumni may have already answered some of the same questions that the students are asking. In a few cases, we have had students looking for a mentor in a very specific field. The Webb Alumni Executive Committee has been able to track down alumni in the desired specialty, and convince them to mentor the student. We have also added the Webb Trustees to the pool of available mentors, as they bring an additional variety of career paths and experience that interests some students.

Once pairings are made and distributed, the onus is on the students to reach out to their mentor and set up their first meeting. Students are provided with a guidance document that they can use to structure their relationship with their mentor and their first few meetings, but we do not set up the meeting for them. We believe that, for a lasting relationship to be built, mentor and mentee have to be willing to put in the effort and time. The problem is generally not the mentor. Mentors are typically excited to be involved in the program and often e-mail us to complain that the mentee has not reached out to set up a meeting. We send a reminder e-mail to all the mentees one week after they have been paired to remind them to contact their mentor, but that is our last effort to make the pairing work. We believe the program should be voluntary. Students are often forced into well-meaning programs, but get started on the wrong foot because the program is mandatory. However, we are always happy to pair a student with another mentor if they realize down the line that they want to participate.

High percentage

The class of 2017 was the first class paired and of 18 students, 15 requested mentors. One year later, six were still regularly communicating with their mentors. We recently discussed our program and processes with Jackson Boyar, an expert in mentoring for Shearwater International. He helped reinforce our belief that the program should be driven by the students, but he was astonished by the high percentage of pairings still communicating after a year. Hannah Wistort



Webb mentee Hannah Wistort '17.



Webb mentee Marshall Fettig '17.

is among those still in touch with her mentor, telling us, "I find it is an awesome opportunity to speak with an industry leader about current events and some of the strengths and weaknesses of the industry. It has enabled me to gain perspective and look beyond just the place I go to work every day." Also from the class of 2017, Marshal Fettig says that his mentor has "helped me edit applications and correspondence and lent me perspective on numerous occasions. I truthfully can't believe how valuable the mentorship program has been."

To an extent, the mentoring program simply formalized something that already existed. Students have historically sought mentors inside or outside the industry and reached out to alumni for advice and guidance. A good alumni association exists for the students of the college as much as anything else. We hope that by supporting and encouraging connections between alumni and students nearing matriculation, we can foster long-term direct engagement between alumni, industry, trustees, and Webb. **MT**

Satchel Douglas *is a sailor, naval architect, and marine engineer with Bruce S. Rosenblatt and Associates.* ***Sean Murphy*** *is a naval architect and engineer surveyor with Atlantic Marine Associates, based in Savannah, GA.*

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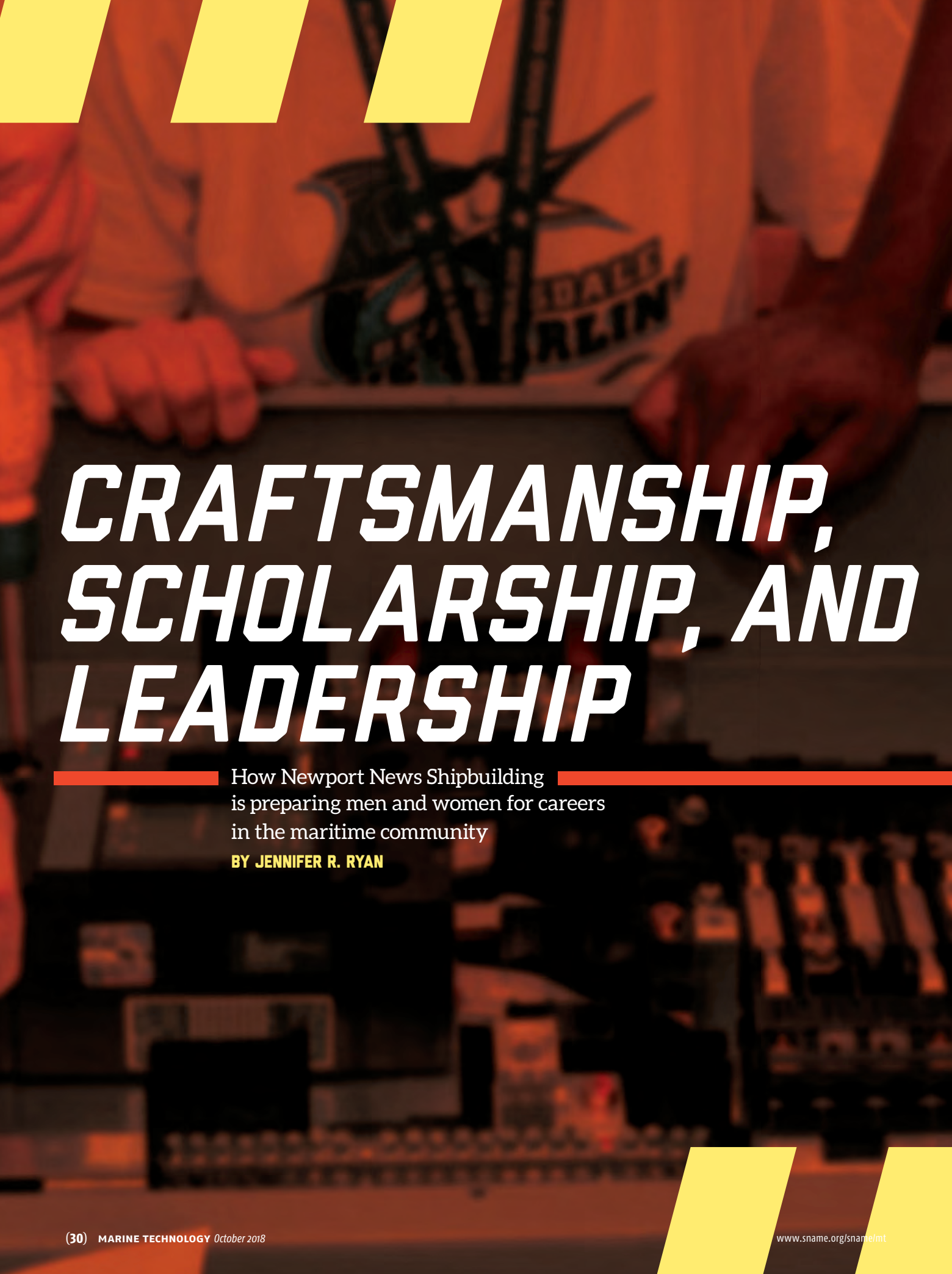
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CRAFTSMANSHIP, SCHOLARSHIP, AND LEADERSHIP

How Newport News Shipbuilding is preparing men and women for careers in the maritime community

BY JENNIFER R. RYAN

Maintenance Electrician Apprentice Graduate Dylan Hogge and Maintenance Electrician Apprentices Tatiana Burkhart and Aaron Davidson install the main circuit breaker for an electrical panel.



CRAFTSMANSHIP, SCHOLARSHIP, AND LEADERSHIP



Classes are held in the new Apprentice School building, which opened in December 2013.

Apprentice programs, as an alternative to a traditional four-year college, have received increased attention in recent years. With the cost of higher education increasing at an unsustainable rate and degree completion rates decreasing, apprenticeships offer a viable alternative. According to an April 2017 article in *USA Today*, a recent study showed that 68% of 2015 bachelor's degree recipients graduated with student loan debt, and the average was $30,100 per borrower. In contrast, apprentices graduate without any student debt.

The shipbuilding industry has its own collection of apprentice programs. The Apprentice School, our apprentice program at Newport News Shipbuilding (NNS) in Newport News, VA is 99 years old and going strong.

On July 1, 1919, Homer L. Ferguson, president and general manager of Newport News Shipbuilding and Dry Dock Company, issued Executive Order #24, authorizing pay for apprentices for classroom instruction during the workday. While that was the beginning of The Apprentice School, it was not the beginning of apprenticeships at the shipyard. Starting in the late 1800s, apprenticeships existed within the company, but the program was not formalized. Apprentices learned by over-the-shoulder training, watching experienced craftsmen do the work. The training was expanded in 1918 to include classroom education in the evening, but it proved impractical for apprentices to work during the day and then attend classes. Ferguson realized it was important to create a formal apprentice program due to a lack of skilled labor for shipbuilding.

Executive Order #24 established guidelines for the four-year program regarding trades, length of apprenticeship, pay, supervision, and a minimum age of 16. Some of the original trades still exist, such as electrician and welder, but others like boilermaker and blacksmith are no longer part of the program. Apprentices attended class two half days a week during working hours and, at the completion of the program, each apprentice was given a certificate and a $100 cash bonus.

Today, The Apprentice School offers apprenticeships in 19 trades and 8 optional advanced programs. Advanced programs include cost estimator, marine designer, nuclear test technician, and modeling and simulation. The school is accredited by the Commission of the Council on Occupational Education and registered with the Virginia Apprenticeship Council. Apprentices complete the program in 4 to 5 years with 1,000 hours of classroom instruction and 7,000 hours of on-the-job training. The school partners with Thomas Nelson Community College and Tidewater Community College to offer associate degrees in technical studies, business administration, engineering technology, and engineering. Additionally, through the Professional Development Program, a select few apprentices with associate degrees in engineering can continue their studies at nearby Old Dominion University and complete a bachelor's degree in engineering.

More than 10,000 apprentices have graduated since 1919. The guiding principles of craftsmanship, scholarship, and leadership have kept the program going and enabled its success.

Craftsmanship

Apprentices are supervised by craft instructors during the 7,000 hours spent learning their trade. All craft instructors are apprentice graduates and work in the trade in which they



Shipfitter apprentice graduate Courtney White completed her associate degree in mechanical engineering technology and apprenticeship in 2017. She also played basketball for The Apprentice School.

trained. Apprentices rotate to new assignments twice a year within their trade, giving them the opportunity to work on different products, including Virginia class submarines, the new construction of Ford class aircraft carriers, and the overhaul of Nimitz class aircraft carriers. Performance on the job is evaluated monthly by craft instructors to track the apprentices' skill progress and they work alongside other apprentices and experienced craftsmen/women to learn what is needed to be successful in their craft. Some trades have an apprentice gallery where training can occur before working directly on a submarine or ship. In the first year of their apprenticeship, they spend three days of the week working "on the waterfront" and two days of the week in the classroom.

Scholarship

As part of the classroom instruction, all apprentices complete the World Class Shipbuilding Curriculum (WCSC) during the first year of their apprenticeship. This curriculum includes 13 basic courses in mathematics, physics, mechanics, drafting, ship construction, business, computers, and communications. These classes are taught in four ten-week terms by academic instructors who are full-time employees of Newport News Shipbuilding. The academic instructors are all subject matter experts within their field with a minimum of a master's degree. While these courses seem basic in nature, like Technical Mathematics II—a combination of geometry and trigonometry—application within these courses is shipbuilding-specific. Calculating the volume of a sphere is linked to a spherical liquefied natural gas tank. Total area and volume are calculated for a ballast wing tank. A concerted effort is made to link the information studied in the classroom with the vessels built in the shipyard. This instruction goes beyond training to focus on education.

EXECUTIVE ORDER #24 ESTABLISHED GUIDELINES FOR THE FOUR-YEAR PROGRAM REGARDING TRADES, LENGTH OF APPRENTICESHIP, PAY, SUPERVISION, AND A MINIMUM AGE OF 16.

After the first year, apprentices with a 3.0 GPA or higher and no course grade below a C can participate in the optional pre-advanced program. During these three semesters, the

CRAFTSMANSHIP, SCHOLARSHIP, AND LEADERSHIP



Rigger apprentice Jeremiah Workman stands watch while work is done on the dry dock 12 gate.



Molder apprentice Peter Watson prepares a pattern for the foundry.

apprentices continue to work on the waterfront and take classes toward an associate degree in engineering, engineering technology, and business administration. Upon completion, their performance is reevaluated and they go through a selection process where they can apply for one of the advanced optional programs and select their associate degree path. This provides an opportunity to assess their performance twice, at the conclusion of WCSC and pre-advanced courses. There is a separate course track for those pursuing an associate degree in technical studies that begins after completion of the WCSC courses.

APPRENTICES COMPLETE THE PROGRAM IN 4 TO 5 YEARS WITH 1,000 HOURS OF CLASSROOM INSTRUCTION AND 7,000 HOURS OF ON-THE-JOB TRAINING.

Leadership

Apprentices are given opportunities within class, on-the-job, and through special programs to hone their leadership skills. Within NNS, approximately 15% of the workforce and 50% of the waterfront management are apprentice graduates. The Apprentice School is the program that provides leaders for the shipyard. At this time, apprentice graduates occupy positions at NNS from foreman to vice president and in 1992, W. R. (Pat) Phillips, a 1954 design apprentice graduate, became the president and CEO of NNS.

The school has several programs to help develop leadership within the framework of the school. Frontline FAST is a developmental journey designed to give apprentices who aspire to be frontline supervisors the right combination of skills and behaviors required to lead teams of shipbuilders. Apprentices are guided through one-on-one coaching and advising sessions, professional facilitation and guidance, and online collaborative discussions. Participating together in well-defined developmental experiences, they explore concepts and connections, exercise fundamental knowledge elements, and execute what they have learned through a combination of special job assignments and make-up foreman positions. The Apprentice School Leadership Experience is also for trades apprentices. They attend an immersive, weeklong session examining leadership styles and skills with business and history professors at the College of William & Mary.

Because The Apprentice School is part of NNS, all apprentices are also employees. As of August 2018, starting pay is $17.79 per hour, and they are paid for their time



Inside machinist apprentice Ashley Ober, who earned her associate degree in mechanical engineering technology, uses pitch micrometers to check the pitch diameter of a threaded part on an engine lathe.

in the classroom and on the waterfront. By the time they graduate, they will be making more than $28 per hour and not have any student debt. More than 10,000 graduates have walked across the stage and completed their apprenticeships since 1919, including the first African-American in 1960 and the first female in 1976. The current student body is more diverse as 18% of today's 768 apprentices are female and 32% are people of color. In addition to diversity in race and gender, the ages of apprentices now vary from recent high school graduate to middle-aged.

In addition to a vigorous waterfront craft training program and practical academic program, the school has a student association and collegiate athletics. Athletics offer additional opportunities for leadership off the jobsite, as does the Apprentice School Student Association (ASSA). The ASSA is responsible for apprentice educational and social activities, community service, and represents the student body. It also is the parent organization of the student societies, including Engineering and Robotics Club, Bass Club, Society of Manufacturing Engineering, Jaycees, and SNAME. Through these professional societies, the apprentices practice craftsmanship, scholarship, and leadership.

SNAME student section and boat design competition

The Apprentice School SNAME Student Section was started in 2005. Dick Boutwell, former manager of training, was the first faculty advisor and was instrumental in the creation of the student section and the boat design competition.

HIGH SCHOOL STUDENTS WERE CHALLENGED TO DESIGN A SMALL BOAT USING ONE-EIGHTH-INCH SHEET METAL TO CARRY A PAYLOAD OF 200 LBS. OF SAND.

The student section wanted to create a competition for high school students that exposed them to science, technology, engineering, and mathematics (STEM) principles relating specifically to shipbuilding. In Fall 2007, the first competition began. High school students were challenged to design a small boat using one-eighth-inch sheet metal to carry a payload of 200 lbs. of sand. The students were required to create a design history notebook and design and manufacturing drawings, and to perform hydrostatic calculations. Their submittals were judged and the top two boats were built by apprentices in the shipyard. Those boats competed in high speed and maneuverability races and were judged on the accuracy of their calculations. In Spring 2008, *The Falcons* from York High School (Yorktown, VA) and *Sink Oar Swim* from Advanced Technical Center (Virginia Beach, VA) faced off, with *Sink Oar Swim* bringing home the trophy.

The competition has grown during the last 11 years. It started with participation from high schools in the Tidewater area of Virginia and today includes competitors from North Carolina, Virginia, Maryland, and New Jersey. More than 2,300 students have participated, averaging 210 annually. This year's competition saw 214 students form 47 teams from 17 cities. Another area of growth was in the number of female participants, 21%, which is the highest percentage to date. Almost 70% of the 47 teams submitted the final design package containing the design history notebook, design and manufacturing drawings, and hydrostatic calculations. Now instead of two finalists, there are four finalists that compete in the race day event. The 2018 finalists were *Barracuda Legacy* from Advanced Technical Center, *Cruise Control* from Walter Johnson High School, *Poolin' Around* from Jamestown High School, and *Water We Doing?* from Briar Wood High School. On May 5, the 11th competition concluded with *Cruise Control* from Walter Johnson High School in Bethesda, MD winning to become the first high school outside of Virginia to be champion.

This competition gives high school students an opportunity to learn about design. They develop a concept, create drawings, and calculate weight and hydrostatics. Sometimes at this point, they discover that their concept is flawed and that they must make modifications or even completely redesign their boat. The



Two of the 2018 finalists in the boat design competition, *Poolin' Around* from Jamestown High School, and *Water We Doing?* from Briar Wood High School.



Boat design competition lead Tim Mills (left) and faculty advisor Jennifer Ryan (right) stand with the 2018 winning team, *Cruise Control* from Walter Johnson High School.

design guidelines state the mission for the vessel and identify the amounts of material provided and restrictions regarding dimensions. As the students continue around the design spiral, they complete their manufacturing drawings, finish their hydrostatic calculations, and ensure that the weight of their boat equals the displacement. If they are able to do this and still have the minimum 6 in. of freeboard, then they complete their design package and submit it in December. They also learn valuable lessons about leadership and teamwork. They learn that design is an iterative process. Lastly, they learn about the maritime industry and available career options.

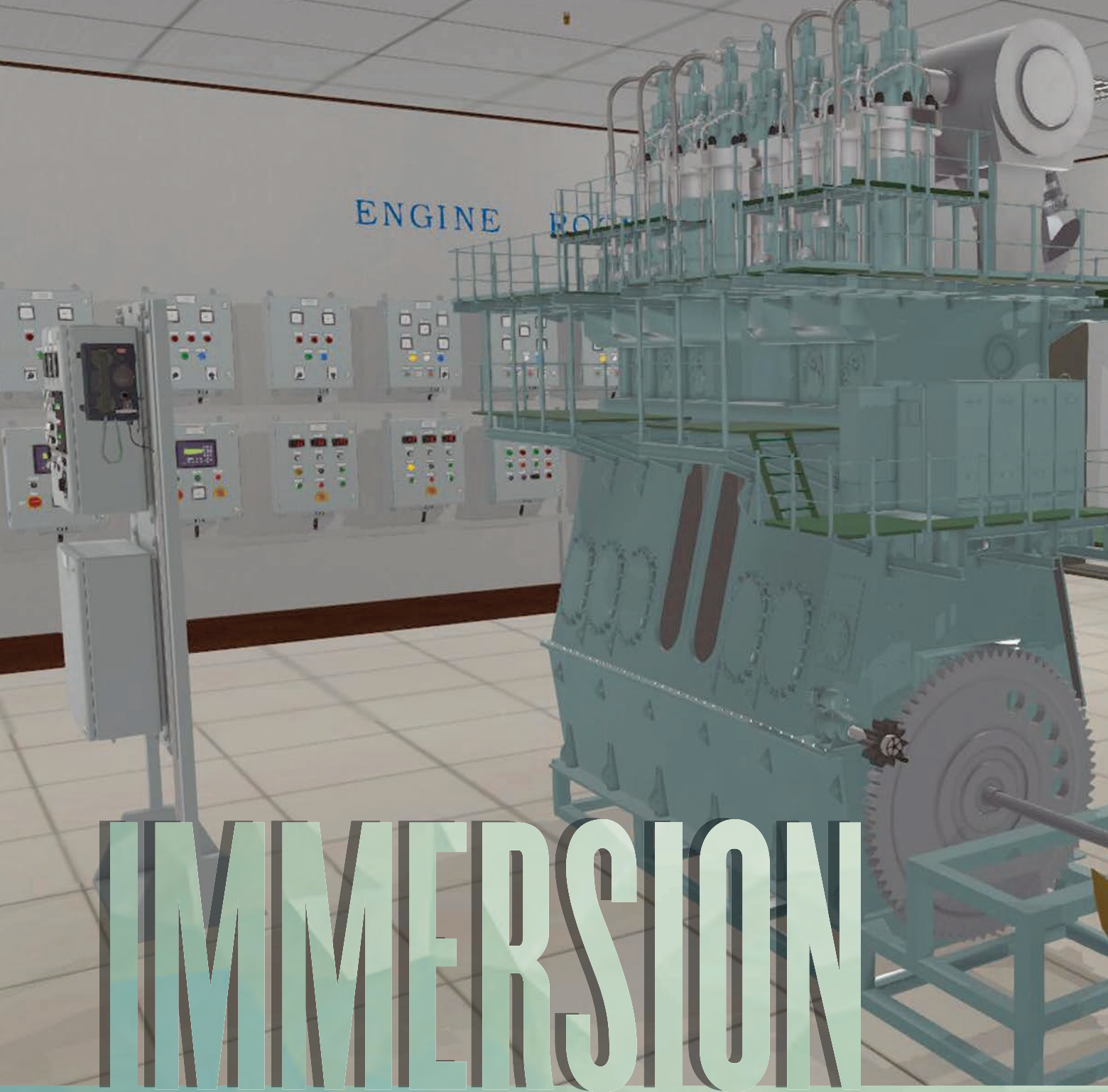
Cooperative competition

While much of the competition's focus is on the high school participants, the apprentices conducting the competition also learn. The boats are constructed by sheet metal apprentices in the sheet metal gallery practicing their craft. The SNAME student members also volunteer as leads and co-leads for different areas of the competition, such as guidelines, site, and steering and propulsion. They learn important skills, including project management, networking, communication, leadership, and teamwork. A lot of activity occurs behind the scenes to ensure the competition operates smoothly and continues to grow from year to year, and apprentices are the ones responsible. Apprentices learn the importance of planning and testing before the execution. Additionally, the vice chair of the student section is the lead for the competition. He or she also learns quite a bit regarding team management and public speaking.

Some of the 2,300-plus high school students that have participated have gone on to pursue STEM-related degrees at Virginia Tech, the United States Naval Academy, and The Apprentice School. The 2016-2017 chair and secretary/treasurer of The Apprentice School student section participated in the Boat Design Competition when they were in high school. Relationships have been forged between The Apprentice School SNAME student section and the student sections of Webb Institute, University of Michigan, and Virginia Tech through the collaboration and judging of the designs. The competition has received national recognition through articles in such publications as the *Journal of Ship Production* (SNAME), *Technology and Engineering Teacher*, and *BoatUS magazine*.

The Apprentice School will celebrate its 100th anniversary on July 1, 2019. The school will continue the legacy of developing men and women for careers in shipbuilding. In addition, the student SNAME section will continue its outreach in engaging high school students in a STEM-related shipbuilding competition, exposing them to the joys and trials of design and the career opportunities available in the maritime community. **MT**

Jennifer R. Ryan, PE, *is an academic instructor at The Apprentice School in Newport News, VA.*



IMMERSION in the ENGINE ROOM

A collaborative virtual reality training system for marine engineers

BY YANGHUI TAN, JUNDONG ZHANG, CHUNYANG NIU, AND SIBO ZHAO



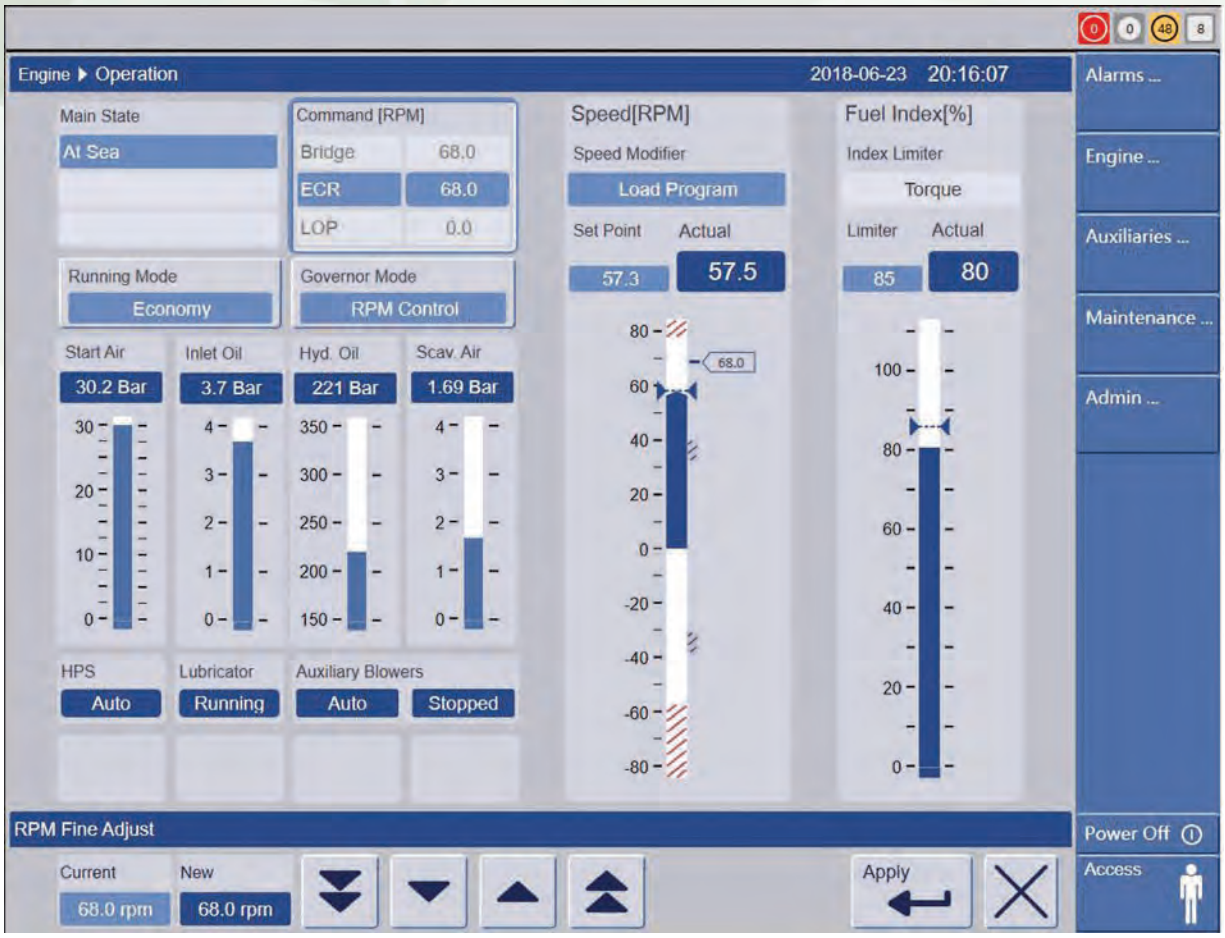
Running of a main engine model in the virtual laboratory at Dalian Maritime University.

A marine engine room simulator is a crucial piece of equipment for the training, evaluation, and examination of marine engineers. Because the marine engine room simulator was listed as a necessary tool for crew training by the International Maritime Organization through the amendment of STCW78/95 in Manila, the marine engine room simulator has gone through a rapid development process that has been driven by huge demand for crew training. Most maritime academies and related training institutions have invested a great deal in the construction of marine engine room simulator laboratories.

The traditional semi-physical marine engine room simulator laboratory includes a main switchboard; an engine control console; a bridge control console; a large dynamic simulation panel; a main engine model; a local control box of each equipment in the engine room; a signal acquisition and communication module; and other electronic components. However, a complex structure; high cost; a long development cycle; a large number of vulnerable components; a high failure rate; difficult maintenance and upgrading; and low training efficiency make this type of simulator a huge burden for most users.

Due to the disadvantages of existing marine engine room simulator laboratories, a collaborative virtual reality (VR) training system—a complement to the traditional hands-on laboratory—has been developed at our school, Dalian Maritime University, in Dalian, China. The system is based on virtual reality and Internet technology. With this system, students can be trained collaboratively and remotely in a 3D virtual laboratory formed by computers.

At present, the virtual reality systems can be divided into four categories: desktop VR, distributed VR, immersive VR, and augmented VR. Considering the hardware cost and the interactive content of the system, desktop virtual reality was selected to develop this system. After all, not everyone can afford expensive hardware. Although a desktop virtual reality system has some disadvantages in terms of immersion, the varied interactive content, flexible interactive means, simple hardware device requirements, and 3D scenes without vertigo make it sufficient for training marine engineers.



MOP of main engine on engine control console.

The core of this simulator based on VR and Internet technology is just computer software with a low cost, short development cycle, low failure rate, easy maintenance and upgrading, and high training efficiency. The virtual lab is composed of a user computer; a cloud server; team collaboration client software (client); model end software of marine engine simulator (model end); two-dimensional human-computer interaction interface (2D end); and a three-dimensional human-computer interaction interface (3D end). The cloud server is the data transceiver center, the client is the simulator management and collaboration management platform, the model end is the logical simulation center, and the 2D and 3D ends are the user interfaces for user operation and system state display.

Development process

The virtual laboratory reconstructs a real laboratory scene on the computer, using 3D virtual devices to replace real world devices. To improve the fidelity of the virtual environment, it is necessary to ensure that the models are accurate. The finer the models and textures, the more realistic the 3D scene is, but that requires higher computer performance. For the best user experience, we need to balance the two.

The 3D models are built on the basis of laboratory construction drawings and image data by 3DS MAX software. Considering the complexity of the objects that need to be modeled and the effective management of the 3D models, the naming of the models needs to follow tree rules. Also, interactive devices and fixed immovable devices need to be distinguished. For fixed and stationary devices, only the appearance model of the device is needed. For devices that need to interact in the later stage, we should consider their movement processes and models separately.

Virtual characters are the representation of trainees in the 3D virtual environment. The actions and behaviors of virtual characters are controlled by trainees, and they can enhance the trainees' sense of immersion and make them mistakenly believe that they are personally in the scene. Virtual characters can arouse students' interest in learning and, more importantly, the solemn professional clothing of virtual characters also is conducive to enhancing students'

Table 1: Modeling of User Behaviors

INPUT DEVICE	OPERATION MODE	SYSTEM OUTPUT
KEYBOARD	W/S A/D F/G ESC Ctrl Space F3	Forward/backward Left/right Zoom in/zoom out Back Squat Jump View map
MOUSE	Left click Right button drag Left button drag	Button up/down, knob rotation View rotation Push/pull telegraph

Table 2: Modeling of Virtual Device Behaviors

VIRTUAL DEVICE	SYSTEM OUTPUT
INDICATOR LAMP, ALARM LAMP, INDOOR LIGHT, PANEL LIGHT	Adjust the self-luminescence of the material
BUTTON	Move along an axis
MULTIPLE KNOBS, SPEED CONTROLS, ETC.	Rotate around an axis
POINTER METER	Pointer rotate around an axis
EMERGENCY STOP BUTTON	Rotate around and move along an axis
GROUP ALARM	Adjust the self-luminescence of the material
BAR GRAPH METER, OIL LEVEL METER, THERMOMETER	Change the scale of a model piece along a certain axis
LED DIGITAL INSTRUMENT	Display and hide digital maps with scripts
LOW VOLTAGE CIRCUIT BREAKER	Switch handle rotate around an axis
AIR SWITCH	Switch handle rotate around an axis
TELEGRAPH	Move along an axis
DYNAMIC DISPLAY SYSTEM PIPELINE	Change the material self-luminescence on the model sheet at a certain time interval
PROPELLER, CRANKSHAFT, FLYWHEEL	Rotate around the axis of the center line of the output shaft of the main engine
TURNING GEAR	Rotate around the center line of the output shaft of the turning gear
LARGE END OF CONNECTING ROD	Circumferential movement with crank pin
SMALL END OF CONNECTING ROD	Translational along an axis under the restriction of the large end of the connecting rod and the crosshead guide rail
CROSS HEAD, PISTON ROD, AND PISTON	Translational along an axis driven by the small end of the connecting rod
HAND PUMP	Swing around a certain axis

sense of professional identity. The geometric model of the virtual characters is built through the 3DS MAX software. The appearance of clothes, hair, skin, and other characteristics is realized through the texture map, and the action law is realized through the skeleton model.

The interaction of a virtual reality system reflects its understanding and feedback on human body movements or language, and natural interaction is the ultimate goal. Therefore, the interaction behaviors can be divided into two types. One is human behavior input, and the other is the feedback of the system. The virtual laboratory system developed at Dalian Maritime University belongs to the desktop VR system. The user's input behavior is relatively inflexible and less than natural, which is reflected in the operation of the mouse and keyboard.

For the variety of interaction points of the virtual laboratory, the action rules of each interaction point are different, so there are many kinds of feedback of the system. The interactive device is bound with scripts based on the kinematic model or illumination model of the device. In the scripts, data interface is retained to facilitate data communication with the model end of the simulator.

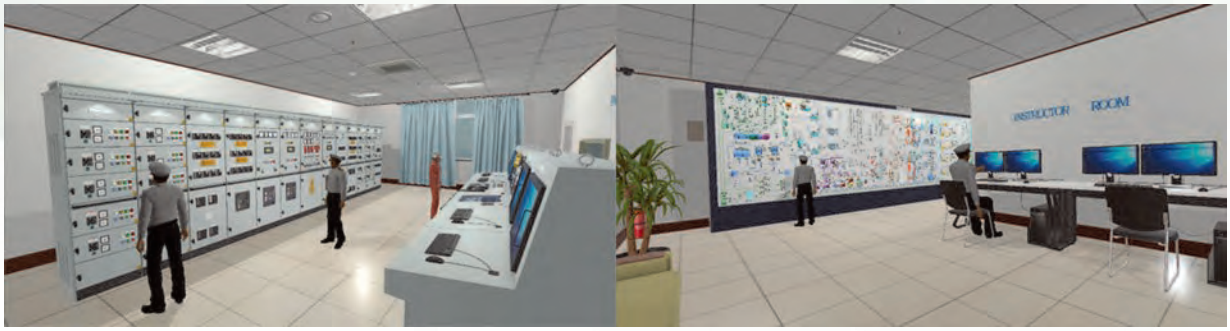
Roaming in the 3D virtual scene is a simulation of human walking in the real world. The construction of roaming scenes needs to import the established 3D models into the Unity3D engine in FBX format. The implementation of the roaming function requires the movement and rotation of the role camera. The role camera is equivalent to human eyes, and the scene recorded by the camera is the scene that people can see. The role camera is bound to the character model, and the camera can move along with the movement of the character model, and finally, the virtual character's roaming in the 3D virtual scene is realized.

Collaborative training

Of course, vessel crews usually work collaboratively onboard. Training in a collaborative VR environment can significantly improve the efficiency of training. With this system, we developed team collaboration management software based on the collaborative working mode. Team collaboration software includes server side and client side components. It has functions of simulator program management, user management, authority setting, team training, and so forth. The key part of developing this system is to deal with the functions of

The actions and behaviors of virtual characters are controlled by trainees, and they can enhance the trainees' sense of immersion.

IMMERSION in the ENGINE ROOM



3D scenes of collaborative training in the virtual lab at Dalian.

team collaborative information interaction, scene role synchronization, instant messaging service, team training, and network communication.

Team collaborative training is the simulation of working mode onboard, aiming at enhancing the trainees' teamwork ability. At present, the training roles supported by this system include: chief engineer, second engineer, third engineer, forth engineer, chief electronic engineer, and so on. The first trainee entering the virtual ship will become the administrator of that virtual ship. Before starting training, the administrator must select a system that needs training. Currently, the training system supported by this model includes: VLCC simulator, container ship simulator, offshore vessel simulator, coast guard ship simulator, liquefied natural gas ship simulator, and a simulator of the training ship of Dalian Maritime University.



Starting of the main engine using a telegraph in the engine control room.

The trainees who join the virtual ship can only be trained according to the simulator selected by the first trainee. The training system starts automatically after the administrator of the virtual ship clicks the start button. In the same virtual ship, only the administrator computer can run the model end, and the other user computers can only run the 2D and 3D ends. For a trainee who joins the training system midway, the state synchronization will be automatically carried out after obtaining the administrator's permission. Of course, the trainee also can join the training system as a spectator to watch other trainees' training.

In the training process, trainees can instantly chat via an online instant messaging system. The chat is conducted through multicast, and the content is visible to all the trainees in the virtual ship. The higher-grade training roles can send command information to the lower-grade training roles, and the lower-grade training roles can report the equipment parameters, alarm values, and task completion to the higher-grade training roles. In 3D scenes, trainees can choose to train in the first person or the third person. When choosing the first-person role, the user cannot see himself or herself; only the other trainees are visible to him or her. When choosing the third person role, the user can see all the trainees including himself or herself.

The system employs a complex logic simulation program. It not only simulates the visual effects of lights, switches, buttons, and propellers; it also simulates the sound effect of equipment. This enables all the systems and equipment to run as in a real engine room.

Trainees can implement all operations on the devices in a virtual environment and they can monitor the working state of the devices. The main simulation systems include main engine and propulsion system; main engine remote control system; monitoring and alarm system; LO system; FO system; seawater system; cooling fresh water system; and air compressed system. The starting process of the main engine serves as an example. Before starting the main engine, it is necessary to check whether the various starting conditions are available. After the fuel oil system, the lubricating oil system and the starting air system are prepared. The trainee

should check the indicator valve, turning gear, and control position. Here we start the main engine in the engine control room, so we switch the control position to ECR.

Once the main state on the MOP of the main engine becomes standby, it indicates that the main engine is ready to start. Once we push the telegraph to DEAD SLOW, the main engine will be started. Then we slowly push the telegraph to NAV FULL. In this process, we can see the speed of the main engine increases slowly in the program, which is a result of the main engine mathematical model according to the actual running law of the main engine. Not only is the engine speed simulated, but also the exhaust temperature; lubricating oil temperature; lubricating oil pressure; turbocharger speed; cooling water temperature; main engine power; fuel consumption; and many other parameters. All of the parameters can change dynamically according to the working condition of the main engine. We can check the main engine revolution, ship speed, and other parameters through the meters on the engine control console or on the MOP of the main engine. When the main engine is started successfully, the model of the main engine will run synchronously.

When the trainees finish training, we need to know the training effect quantitatively in time. The traditional assessment method is to give a score by the examiner, which is subject to the subjective influence of the examiner. In order to evaluate the trainees' training effect objectively, an evaluation knowledge base was established based on Seafarer's Ability Assessment Standard of People's Republic of China, a set of guidelines issued by the Maritime Safety Administration of the People's Republic of China. During the training process, some system variables will be selected as the source data for evaluation according to the evaluation knowledge base. These selected variables will be recorded and stored in real time. A fuzzy comprehensive evaluation algorithm (based on the theory of fuzzy mathematics) is used to evaluate all the scoring items according to the source data recorded during the training process. Therefore, the scores will be given based solely on the performance of the trainees.

It not only simulates the visual effects of lights, switches, buttons, and propellers; it also simulates the sound effect of equipment.

Auxiliary function

The environment of the virtual lab is just the abstract of the actual marine engine room environment. In order to increase the trainees' sense of presence, this system added animation of an actual marine engine room into the virtual screen of the virtual lab. Through this system, the trainees can learn not only how to operate the equipment, but also understand the internal environment of the actual marine engine room.

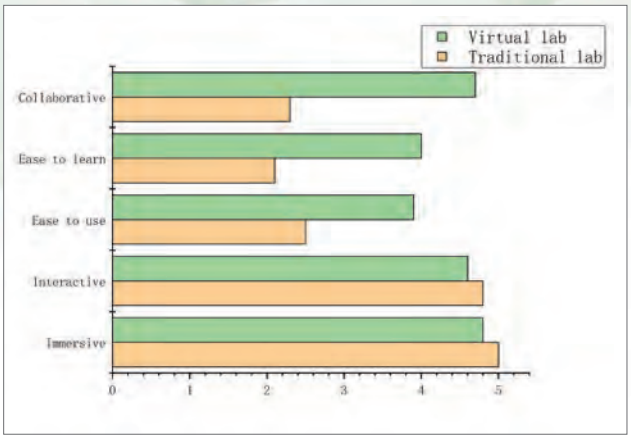


Selection of training system.

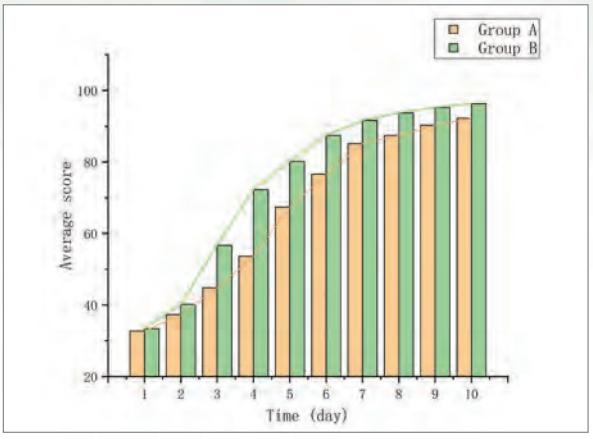
In addition, to enhance the coupling of the two-dimensional system and the three-dimensional system, the interface intelligent jump function is added. The trainee can click the interactive point to jump from a three-dimensional scene to a two-dimensional scene, or jump from a two-dimensional interface to a three-dimensional scene. The purpose of setting up the intelligent jump function is to make the system easier to use.

Applied practice

This virtual laboratory has been tested with 20 students majoring in marine engineering at Dalian Maritime University. All of the students who participated in the test have knowledge of marine engineering, and they tried both the virtual laboratory and the traditional hands-on laboratory. They then filled out questionnaires about the two systems to evaluate immersion, interaction, ease of use, and ease of learning. Each aspect was evaluated on a scale from 0 to 5.



Evaluation of the two training systems.



Training effect of the two systems.

It was found that the virtual laboratory has a much higher score of ease to use and ease of learning than the traditional hands-on laboratory. This means that the virtual laboratory has a better user experience. As for the immersion and interaction, the virtual laboratory is a little lower than the traditional laboratory. This means that both systems have good training results, the traditional laboratory being only slightly better. After experiencing both systems, 18 of 20 students preferred the training experience with the virtual laboratory and said they would prefer to use it in the future.

To evaluate the training effect, another 20 students majoring in marine engineering in Dalian Maritime University were selected to test this system. To exclude the impact of the preceding test on this test, these students did not participate in the preceding test; they all have knowledge of marine engineering but have not experienced any similar training. The students were divided into two groups: group A trained in the traditional laboratory and group B in the virtual laboratory. They were trained for 10 days separately, and their examination results were recorded every day.

After experiencing both systems, 18 of 20 students preferred the training experience with the virtual laboratory and said they would prefer to use it in the future.

It was found that student trainees in group A learned more quickly than those in group B, which means that the training effect of the virtual laboratory is better. The score curves of both group A and group B first rise slowly, then rise rapidly, then rise slowly again. In the first slowly rising stage, the student trainees need some time to become familiar with the learning environment, which means group A need four days to familiarize themselves with the laboratory environment, while group B need just two days. The reason for this result is probably because the interface intelligent jump function of the virtual laboratory accelerates the cognitive process of students in an unfamiliar environment. In the rapidly rising stage, the student trainees have been familiar with the environment of the laboratory, whose learning efficiency has been greatly improved. In the last slowly rising stage, their learning efficiency has not been reduced, but the higher the score, the less room for improvement.

The student trainees also suggest a couple of limitations of the current virtual laboratory system. First, the users may get tired with long-time use of the virtual laboratory. And second, the interaction devices are only mouse and keyboard, which is not the natural way of the system operation. The user could not feel any sense of presence, which will also reduce immersion in the system.

These limitations are due to the limitations of the software and hardware. With development of the virtual reality technology, especially the human-computer interaction technology, the limitations of this system can be solved in the future.

The virtual laboratory has nearly the same immersion and interaction as the traditional hands-on laboratory, but the virtual laboratory is much easier to use and to learn. The high training efficiency, unlimited number of trainees to be trained at the same time, collaborative training mode, and network remote training will greatly improve the training effect and reduce the cost of training. This will make it a revolutionary tool in the field of marine engineer training. **MT**

Yanghui Tan *is a student majoring in marine engineering at Dalian Maritime University in Dalian, China.* ***Jundong Zhang*** *is a professor at Dalian Maritime University.* ***Chunyang Niu*** *is a student majoring in marine engineering at Dalian Maritime University.* ***Sibo Zhao*** *is a marine engineer employed at Dalian Maritime University.*

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Building the WORK FORCE



How LIFT is trying to refill the talent pipeline for advanced manufacturing

BY EMILY STOVER DEROCCO

In 2013, following years of reports analyzing the state of U.S. manufacturing and the national strategy and federal actions needed to restore U.S. leadership in advanced manufacturing, congress began deliberations on new legislation to support that industry. Much of the debate centered on ways to accelerate the introduction of new technologies to achieve the efficiency and productivity gains required to advance important manufacturing sectors. That legislation—the Revitalize American Manufacturing and Innovation bill—would authorize regional manufacturing institutes across the country, each focused on a unique technology, material, or process. Meanwhile, the Department of Defense's (DOD) Manufacturing and Industrial Base Policy office and its ManTech program launched a series of institutes, including Lightweight Innovations for Tomorrow (LIFT). Currently, there are 14 institutes under the Manufacturing USA umbrella; the Department of Defense funds 8 of them.

LIFT was founded in 2014 as a national institute, with a hub in Detroit, and initial geographic focus extending regionally through the I-75 corridor encompassing Ohio, Michigan, Indiana, Kentucky, and Tennessee. Its manufacturing focus is on lightweight and advanced metals that offer major performance enhancements and greater energy efficiency to improve the performance of many systems in defense, energy, transportation, and engineering products. Lightweight metals have applications across transportation sectors—including shipbuilding—and in wind turbines, medical technology, and alternative energy sources.

With more than 115 members, LIFT represents small, medium, and large enterprises and universities, who together matched $70 million in federal funds from the United States Navy's Office of Naval Research. Since its founding, LIFT has been working with its industry and university members on projects in melt processing, thermo-mechanical processes, powder processing, agile low-cost tooling, coatings, and joining & assembly. These have applications in automotive, aerospace, shipbuilding, railroads, fabrication, and other sectors.

LIFT also has been recognized as the Manufacturing USA leader in workforce education, with a strong belief that technology development without talent development is foolhardy. Working in a space that is not a new material or technology, LIFT understood early on that it had to develop two sets of strategies



Students from the Detroit Public Schools Community District participated in hands-on activities during the MakerMinded kickoff celebration at LIFT in January 2018.

to ensure the availability of an educated and skilled workforce for advanced manufacturing.

The nation needs to address the skills gap in manufacturing that exists today, as critical workforce challenges are common to every sector in U.S. manufacturing. National manufacturing organizations project that there will be more than 3 million jobs available by 2020, including newly generated jobs and replacements from retirements; more than 2 million of those positions may go unfilled due to the skills gap.

At the same time, as new manufacturing processes and technology applications related to lightweight metals continue to evolve in the Institute's innovation lab, LIFT leadership remains committed to aligning talent development strategies to new knowledge, skills, and abilities needed for commercial application of those discoveries.

Both workforce challenges are significant, and LIFT is addressing both. By necessity, the strategies the institute is deploying span many sectors in advanced manufacturing, including the maritime industry and shipbuilding. Initiatives to address the skills gap are designed to be applicable across all sectors and span the entire continuum of education from K-12 to community and technical colleges, universities, and work-based learning in industrial settings. Our work in aligning talent development strategies to specific technology advancements is directly focused on the sectors and pillars of the institute's technology development program, and new workforce preparation initiatives are primarily in postsecondary education and work-based learning in industrial settings.

Technology and talent development

Manufacturing is becoming more cutting-edge every day, and workers are expected to have advanced math skills and scientific prowess to join the workforce and continue driving innovation. Historically, much of the manufacturing workforce has been developed in two education silos: the technician, assembly, and skilled trades through apprenticeships and skilled training programs in vocational education and community colleges; and the engineers in university programs of study.

Now, the infusion of technology across all manufacturing sectors and at all levels of design and production requires the workforce to have multidisciplinary, higher-level skills and a significant set of competencies related to new technologies, materials, and processes. Strong partnerships are needed between post-secondary education and industry. If community and technical colleges and universities are not incorporating the evolving needs of industry into their curriculum and training

opportunities, their students will not be prepared for the world of innovation in advanced manufacturing.

The Aligning Technology and Talent Development initiative is an effort designed by LIFT and led by the Association of Public and Land-grant Universities and the National Center for Manufacturing Sciences. LIFT has established an expert educator team (EET) from universities and community colleges to help identify the knowledge, skills, and abilities that workers at all levels will need to deploy the technologies, materials, and processes created at LIFT. The team is helping to align LIFT technology development plans with training competencies and strategies, strengthening the connection between emerging technologies and educational programs of study by identifying the competencies related to using these technologies in the design and production environments. This helps to better prepare students to enter the workforce after graduation.





Above: The top deck mock-up in progress during the LIFT welding distortion project. Below: The inside of the top deck mock-up during the LIFT welding distortion project.

By necessity, the strategies the institute is deploying span many sectors in advanced manufacturing, including the maritime industry and shipbuilding.

Ultimately, the initiative aims to encourage more industry-driven, technology-aligned work-and-learn curricula in university and community college programs to produce graduates more capable and confident in using new manufacturing technologies and processes. In addition, the effort targets the skills development needs of the incumbent workforce and engaging higher-education institutions in addressing these needs.

Huntington Ingalls Industries' Ingalls Shipbuilding division has led LIFT's Distortion Control project with partners in government: NSWC-Carderock Division and NAVSEA; industry, including the American Bureau of Shipping (ABS), Comau, and ESI; and research, including the University of Michigan, EWI, the Massachusetts Institute of Technology, and the Ohio State University. This project has resulted in innovative computer modeling to better predict where distortion, or warping, will occur when steel plates are welded together, ultimately reconfiguring the welding sequence. Using a United States Coast Guard Cutter unit as a test article, the project team demonstrated a 30% reduction in distortion and a 13% reduction in production costs compared to similar, previous cutter production units.

According to the white paper generated by the project team, dimensional accuracy control from piece-part fabrication to component welding assembly is essential in modern manufacturing in many major industries. Structural lightweight design poses significant new challenges. In shipbuilding, the distortion begins with incoming material and internal handling or storage procedures and is compounded by each subsequent fabrication process. The distortion that can be controlled mostly starts when thin steel plates are butt welded together to create large panels. These deck plate distortions could impact hull quality and structural integrity, and result in increased manufacturing costs and scheduling impact. Distorted decks and bulkheads could compromise the performance of the ship. Additional costs and scheduling delays will be incurred from straightening operations downstream. Both the skilled labor to perform flame straightening on steel structures and the labor to clean up and repaint after straightening can be significant cost factors.

The project team took a four-pronged approach, conducted over a two-year period, which included:

- observing the baseline coast guard cutter production assembly and collecting distortion data at each process step
- fabricating 19 test panels featuring different variables and assembly sequences
- employing integrated computational materials engineering (ICME)



LIFT laboratory operations manager Rich Hoffer provides a tour of the LIFT R&D facility to Detroit Public Schools Community District students.

modeling to establish recommended fitting, welding, and assembly sequences for optimized distortion control
- employing recommended procedures on a full-scale mock-up unit
- detailing process flows to determine the change in cost due to improved technology and reduced distortion.

Many of the basic components of the modeling tools to identify the primary distortion drivers have been developed and are now being integrated and refined into a suite of tools and recommendations for the use of the shop floor worker, designer, and production engineer.

Two teams together

LIFT brought in the EET to work with the distortion control technology team to make recommendations for new training requirements related to the suite of tools being developed. Bringing the two teams together generated significant discussion about the particular challenges in shipbuilding environments. Because development of the shipbuilding workforce has largely been insular to the industry and the companies in it, certain cultural characteristics become ingrained. Such characteristics present challenges, particularly when the broader manufacturing and education environment is connecting with and helping to shape the shipbuilding workforce.

Still, the EET made three recommendations. First, experiential learning practices—on-site work-based learning, work-and-learn, internship, and co-op experiences—for college students, engineers, and shop floor workers are critical to developing competencies in distortion control and many other technologies. Experiential work-and-learn practices create students who are both more knowledgeable about technology and better able to work with technology, and people, in the workplace. Aligned to the distortion control project, educators are recommending development and implementation of an experiential learning toolkit, and suggested that the principal professional society and certifying body, the American Welding Society, create and deliver through work-and-learn curricula, new content related to joining lightweight materials. These work-and-learn modules also could be incorporated into shipyard apprenticeship programs.

Secondly, recognizing that much of the nation's workforce education is provided by community and technical colleges, the educators also encouraged coordination with Weld-ED, the National Science Foundation-funded Advanced Technology Education Center, to develop training content that could become part of a suite of "train the trainer" modules for community and technical college faculty.

And finally, the use of ICME software was significant in this distortion control project, and understanding the costs of modeling and simulation software is often prohibitive in educational institutions. Therefore, the EET recommended that LIFT, and other Manufacturing USA institutes, focus attention on creative ways to provide access to students in advanced manufacturing and engineering pathways to the power and potential of these software tools.

This successful LIFT technology project illustrates the important strides that the Manufacturing USA institutes, with their industry and government partners, are making to solve real-world industry challenges. The partnership described between the LIFT EET and the distortion control technology team also points to the importance of aligning technology and talent development to enable deployment of successful solutions as rapidly as possible.

Addressing the skills gap

According to a report published by the Maritime Administration and cited by the National Maritime Education Council, total economic activity associated with the shipbuilding and repair industry in 2013 accounted for 399,420 jobs, some $25 billion in labor income, and more than $37 billion in GDP. Each direct job in the shipbuilding and repair industry leads to another 2.7 jobs nationally, and each



Members of the LIFT and Huntington Ingalls project team in front of the coast guard cutter top deck mock-up used in the welding distortion project.

dollar of direct labor income leads to another $2.03 in labor income in other parts of the economy.

Not unlike virtually all other sectors in manufacturing and construction, the industry faces workforce challenges. These include an aging labor pool, lack of technically skilled workers to replace retirees, high turnover due to the cyclical nature of the industry, and competition from other industry sectors recruiting the same workers for the same skill sets.

Perhaps of even more concern is the need for a more highly educated and skilled maritime workforce, in light of the modernization and expansion of the navy fleet, and technology enhancements across the whole of shipbuilding and sustainment. As the knowledge, skills and abilities needed to be successful in this industry substantially increase, fewer potential workers pursue the necessary education and training to prepare for the jobs and occupations in the maritime sector.

Additionally, not enough of our students gain a firm foundation in the science, technology, engineering, and math (STEM) skills so critical to this and other sectors.

In recent years, just 18% of bachelor's degrees awarded were in STEM fields, down from 24% two decades ago. Even more alarming, the gender and racial gap within the STEM workforce continues to widen.

The majority of jobs in our economy require at least some postsecondary education and training. The Georgetown Center on Education and the Workforce reports shortages of 3 million workers with associates degrees or higher and 5 million workers with technical certificates and credentials.

The Society of Human Resource Managers has identified the skills shortage in the U.S. as a growing problem that will require innovative efforts by government, educational institutions, and employers. The LIFT team believes that the Manufacturing USA institutes are positioned to confront these issues and design and implement replicable and scalable solutions for advanced manufacturers in the maritime industry and across all of advanced manufacturing. Following are examples of LIFT's work to address the shortage of young people pursuing foundational STEM education and, ultimately, STEM-related careers and to expand the talent pool for manufacturers by targeting important populations.

MakerMinded

The MakerMinded web portal, designed by LIFT with Tennessee Tech University, brings together actionable information, the power of competition, and campaign communications. The purpose is to saturate the learning infrastructure with a manufacturing mindset to bridge the gap between activities and programs that engage and educate youth and the students who can take advantage of them.

Launched in 2016 in Tennessee, then followed by Kentucky, Ohio, and Michigan, MakerMinded harnesses the power of competition

and student-driven campaigns to expand access to advanced manufacturing and STEM learning experiences. Through these transformational experiences, students gain 21st century skills and secure their path to in-demand careers.

Delivering a portfolio of STEM awareness and education activities to schools and students, MakerMinded is a simple, accessible platform including both national and local-level STEM and manufacturing career exploration activities, project-based learning, formal educational resources, and other experiential learning opportunities.

MakerMinded was founded on four core principles that not only change attitudes about STEM and manufacturing, but also drive students and schools to act:

- campaign-style communications: all students and schools work toward a common goal—building awareness and engagement in STEM
- the power of competition: schools compete for points acquired for completing activities, which builds community, unites disconnected students, and empowers all stakeholders
- student-driven programs: students and schools own STEM activities
- Leveraging, not reinventing, successful activities: MakerMinded brings to scale impactful programs and saturates the marketplace with STEM.

In two years, there has been great impact on students' interest and engagement in STEM and advanced manufacturing learning activities. In July 2018, LIFT announced the expansion of MakerMinded to Indiana, Idaho, and West Virginia.

Operation Next

Operation Next is a new model for equipping separating military personnel with the skills and credentials needed for the most in-demand advanced manufacturing civilian careers in the country. Launched in 2017 as a pilot program at Ft. Campbell, it is a hybrid learning program for soldiers within their last six months of service who are still on active duty, providing them the opportunity to earn nationally portable, standards-based, industry recognized credentials. The program currently offers two training tracks: computerized numerical control (CNC) machining and industrial technology maintenance (ITM), but plans are underway to expand skills development. The current training programs lead to credentials from the National Institute for Metalworking Skills, preparing the individual for the most in-demand manufacturing jobs in the U.S.

These deck plate distortions could impact hull quality and structural integrity, and result in increased manufacturing costs and scheduling impact.



Soldiers at Ft. Campbell learn about LIFT's Operation Next during the program's announcement in 2017.

There are many training and educational programs available to those transitioning from military to civilian careers. However, there are several aspects of Operation Next that make it unique. The entire program—either CNC or ITM—can be started and completed within the individual's final six months of service while they are still on active duty. The curriculum has been developed as a hybrid learning program. It is a combination of online learning that can be done at any time on any computer with an Internet connection and hands-on, lab-based learning on real world manufacturing equipment.

In addition, participants get credit for what they already know and can do. Individuals serving in the military often develop technical skills that are clearly transferable to the civilian sector. But often those skills are not articulated in language familiar to employers. Operation Next enables military personnel to get credit for their technical skills, without having to take additional coursework, and have those skills represented in a credential recognized and valued by industry.

Also, employers are engaged throughout Operation Next, not just at the end when it's time to hire. Manufacturers provide plant tours, mentorship, and other workplace experiences so that Operation Next students have a clear understanding of the kind of work they'll be doing and the opportunities for career advancement.

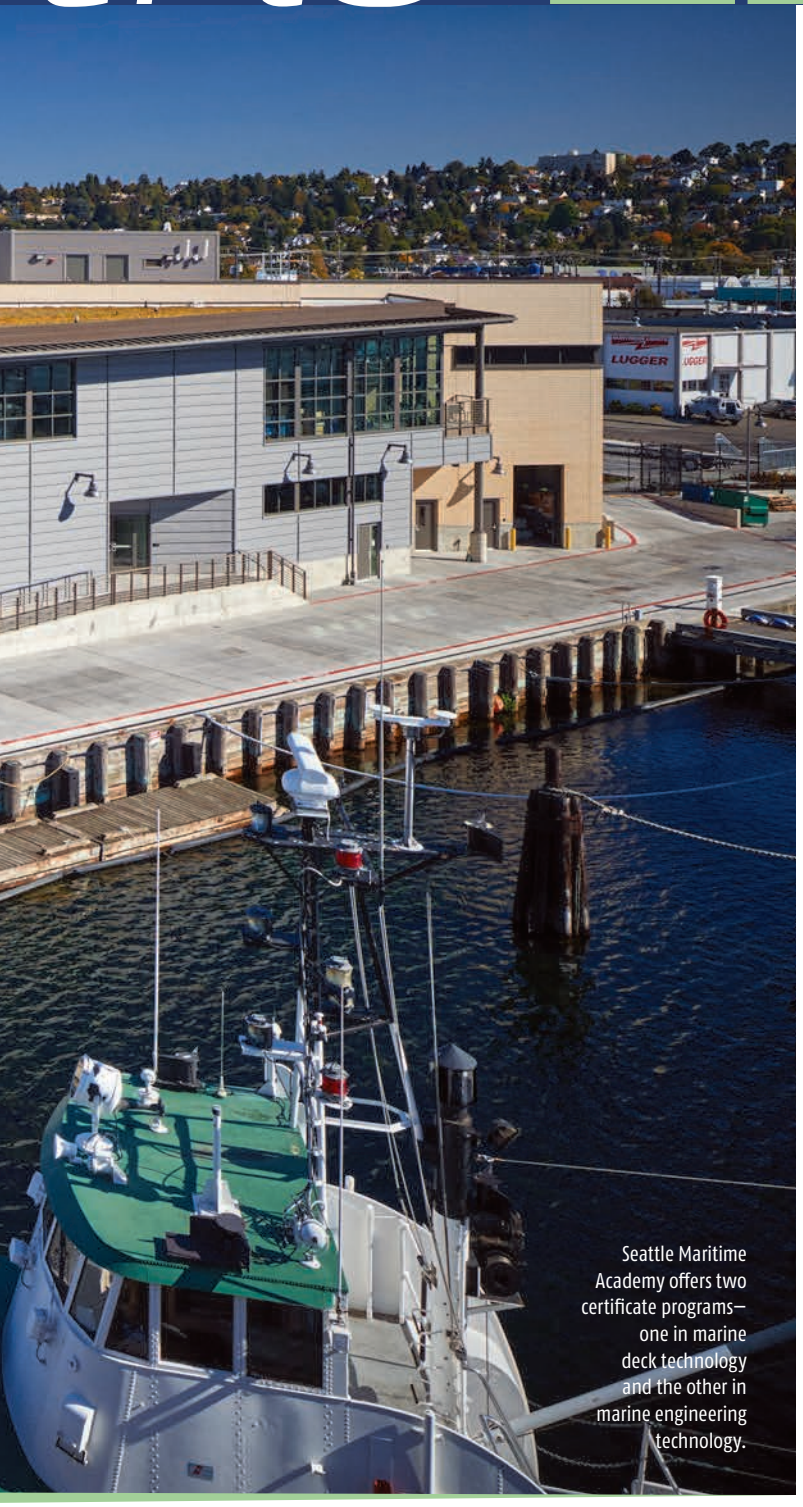
Since LIFT's founding in 2014, the institute has invested in more than 40 education and workforce development initiatives to refill and rebuild the talent pipeline for advanced manufacturing. Our plan to develop the educated and skilled workforce spans both the continuum of jobs in manufacturing where the nation is experiencing a dangerous skills gap, and the continuum of education and training that must be available in communities and states seeking to sustain, grow, and attract manufacturing jobs in their economy. **MT**

Emily Stover DeRocco *is founder and CEO of a Washington, D.C.–based consulting practice linking education, workforce, and economic development assets for competitive advantage.*

Turning on



the Light



Seattle Maritime Academy offers two certificate programs—one in marine deck technology and the other in marine engineering technology.

Seattle Maritime Academy exposes teenagers to opportunities on the water

Editor's note: *Sarah Scherer is director and associate dean of the Seattle Maritime Academy, in Seattle, WA. Douglas R. Kelly,* (mt) *magazine editor, spoke with Scherer about the academy and the ways in which her team engages with young people on maritime issues.*

KELLY: Sarah, your background includes 13 years experience piloting ocean-going vessels, is that right?
SCHERER: Yes.

KELLY: Was that on the West Coast, the Pacific Northwest?
SCHERER: It was all over. I did a little bit of time in the Gulf of Mexico doing supply boat work. I've done tugboat work. I've worked for NOAA on scientific research vessels. I've driven a bunch of army landing crafts in the Marshall Islands. You name it, I've done it.

KELLY: What brought you to Seattle Central College?
SCHERER: I was a safety person in the fishing industry. When I stopped sailing, I worked for Foss Maritime here. I worked for Crowley and had gotten a master's degree in leadership and organizational development and was working there. When I worked for Crowley, I had to go to Florida. I knew that Florida wasn't some place I wanted to stay forever, so I eventually made my way back to the pacific northwest, first in Portland, and was doing something outside of maritime industry, and then realized that I was better suited to the maritime industry, so I moved back up to Seattle. I was working as a safety person for a fishing company and saw this job announcement for the director of the Seattle Maritime Academy. I had already thought about academics and teaching, and when I read the job description, I thought, "This would absolutely use all of my skills. I don't really need a new job, but I was like, "I'm going to see what happens." I did it, and here I am two and a half years later.

KELLY: The Seattle Maritime Academy, I understand, offers two certificate programs. One is in marine deck technology and the other in marine engineering technology. Can



Sarah Scherer is director and associate dean of the Seattle Maritime Academy.

you lay out for us those programs and the type of student at which the two programs are aimed?

SCHERER: Sure. The deck technology program is the path to the wheelhouse. If someone wants to be a captain of a boat or be a mate on a boat or a ship, that's where they would start. [It includes] things like nautical charting and everything from navigation to meteorology to line handling; marlinspike seamanship, which is knots and splicing; deck maintenance; vessel handling…lots of different things. They do nine months of hands-on instruction, broken into three quarters, and then they get an internship…on a commercial vessel somewhere here in the Pacific Northwest or in Alaska, typically. On the engineering side, it's the path to being in the engine room.

The deck technology program is the path to the wheelhouse.

Engineers on ships don't just make sure that the engines run. They do all the auxiliary systems as well. So, they're trained in refrigeration, hydraulics, electricity, steam—you basically do everything. You're making sure that the plumbing is working, the refrigeration systems are working. You're making water. If you're on long trips and on larger boats, you have water makers. [Also, you're] making sure that the deck machinery and all the machinery in the engine room that is separate from the engine is working. They also do nine months of hands-on instruction broken into three quarters, with an internship.

KELLY: For both programs with the at-sea internship, what types of vessels do your students intern on?

SCHERER: This year, they're on everything from Washington State ferries to Lindblad Expeditions, NOAA, Crowley, Foss, Harley, Western Towboat…normally, we have some fishing vessels in the mix. Actually, we do have some engineers out on big factory trawlers. We've run the gamut across the Pacific Northwest, in terms of the different types of vessels. We have two students going out with polar tankers, which is part of ConocoPhillips.

KELLY: When we talked on the phone earlier, you mentioned high school awareness programs. I think we talked about one called Experience Maritime?

SCHERER: Yes, it's funded by Washington Sea Grant and the school pays for part of it as well. It is a four-day maritime awareness program. The first day, they do a little bit of marine safety so…survival suits, lifejackets, how to build a float plan, how to create a personal survival kit. What are the seven steps to survival? What are the emergencies that can happen on vessels? We talk about that in the morning. In the afternoon, they do deck department type stuff. They get tours of the vessels, they get to go in our full mission bridge simulator. They learn how to do simple plots and learn about nautical charts…what the difference is between a nautical chart and a map. Then they do knots, two or three basic nautical knots. The next day, they do engineering in the morning—we give them an overview of what engineers do: diesel engines, refrigeration, hydraulics, electricity. They get to tour our vessels and the engine rooms in the vessels. They also get to go into the engine room simulator.

And then, the afternoon of the second day, they do a module on marine science, how what we do as humans affects the oceans, that it's all one big ocean with different parts. They get prepared to understand the science because the following day, they get to go underway on our training vessel and they actually go out through the Ballard Locks and they go to three real scientific stations and they collect data. There are three or four different stations on the ship, and one is, they do a bongo tow and they get plankton that they categorize onboard the vessel. On one of them, they do a CTD, which is a conductivity temperature and density measurement. Then they go to the bow and they do a water sample with a Niskin model that they can test for pH level and different things. Then they come back through the locks and they come back to the school and they actually get to crunch the data. They look at the plankton under microscopes, they download the data onto a computer for the CTD scan, and they talk about what all that means. On the fourth day, we do career explorations.

Hopefully, in the first three days, we've sparked interest and maybe some passion or even just a thought process that maritime exists and it could be an option. We talk about the different careers in the maritime industry. They do a little research project



Fire extinguisher training in marine safety college certificate classes.

and do presentations on things like tugs and towing… and what do the fishing vessels do around here? Everything from port operations to naval architects, we break down the industry into seven sectors and different groups do different sectors. They look it up on their phone, or we have a document that they can use, and they create a presentation. So, they're doing the research and then we talk about it. Then after lunch, we actually bring in industry partners, and they come in and do a panel. They talk about how they got to where they are, they tell their personal stories, then they talk about their company and share what their company does and what a career path might look like. They go around the room and do that and the students get to ask them questions. After the panel, then we talk about all the ways to get involved and the educational opportunities for those who are interested…what high school programs are out there, what community college programs are out there, what four-year maritime programs are out there, where they could go and come back and work in the maritime industry.

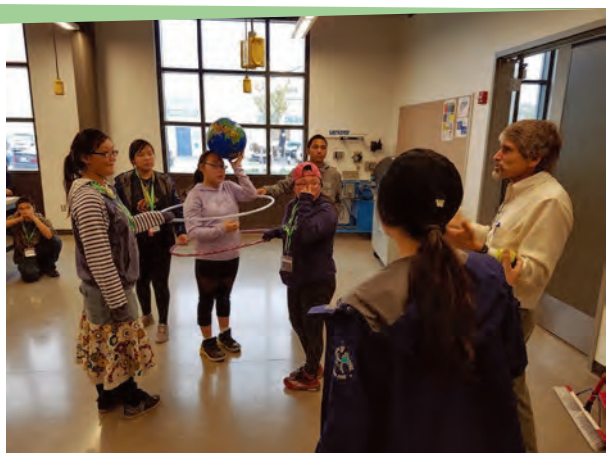
KELLY: What kind of a reaction do you see with these high school students on day one, versus the end of day four? Is this an eye-opener for them?
SCHERER: It is. Most students really don't know that the maritime industry is an option, even though we live in a geographically perfect maritime environment and people go across bridges and see the water on a regular basis. But they don't process that there are jobs out there. We've had many that just say, "I didn't even know that maritime existed, and now I know it's an option."

KELLY: Do you do this program several times a year?
SCHERER: We do it just in the summer time. As per this grant, we do it eight times in the summer or fall-type scenario. The money for this grant runs out this year, so next year, we'll probably keep doing the program but it will be on a more limited scale, so maybe four.

KELLY: How do you get the word out on the program to high school students?
SCHERER: We're starting to build, as part of our Youth Maritime Collaborative, we're actually starting to build those networks in the schools. Actually, one of the action items we have is to build a database of high school counselors, CTE teachers, career technological education teachers, and then community youth education groups…so, girl scouts, boy scouts, those kinds of things, and getting this really big database pulled together that then we can e-mail things out. I e-mail everybody I know in the maritime industry and everybody I know who's not in the maritime industry. We post it on social media, Instagram, Facebook. Right now, typically, it's parents signing up their kids. And we have partnerships with youth education groups like Seattle Goodwill, who has actually started a youth maritime program. Two weeks of this year, we've had groups of about 10 who are from that youth



Students from Coastal Villages Region Fund looking at plankton under a microscope in the Experience Maritime program.



Students from Coastal Villages Region Fund talking about tide cycles as they relate to the earth and the moon in the Experience Maritime program.

maritime program, which helps us really address some of the under-represented populations. We're working on that, in collaboration with the Youth Maritime Collaborative, to get into the schools and particularly to target some of the under-represented populations racially, as well as male versus female because right now, even worldwide, there are not that many women in the maritime industry.

KELLY: That gender split, male versus female students, not just with Experience Maritime, but also with the two certificate programs. What types of split do you see male to female, in both the certificate programs and with the Experience Maritime program?
SCHERER: Well, Experience Maritime…the male to female split is pretty even, then sometimes even more females, but in terms of the actual training programs and the certificate programs in college…in a 16-person deck class, we might have 1 or 2 females, and the same in an 18-person engineering classroom. Last year we had one deck female and two engineering females.

KELLY: That doesn't surprise me too much. [In naval architecture and marine engineering programs in general] it's still heavily weighted in favor of male students.
SCHERER: Yes, when I was sailing, I sailed actively between 1993 and 2005. If I was not on a scientific research vessel, I was typically the only woman.

KELLY: Maybe that's changing somewhat, with [programs like] your Experience Maritime program, with getting more high school girls involved and interested in these types of careers.
SCHERER: We'll see. We've only been doing Experience Maritime…this is the second summer and we've only been doing the Youth Maritime Collaborative for about, well this was the second year of operations on that side. So we don't really have enough data, at this point, to show whether this awareness program is working. People have started asking me now, "Are you getting any responses from this?" But when we're doing high school programs, they can be as young as 13 or 14, coming in to high school. So we may not know for three or four years whether what we're doing is having an impact, because they're not even to the point where they're going to start choosing that. I do think that the sweet spot will be middle school. The reason I say that is because I think there's a lot of really cool middle school-type marine science and maritime programs that people could start getting involved in. Also, to get into the maritime industry, at least on the underway side—to go work on ships—you can't have a felony and you can't have a DUI. Well, you can, but it makes it really, really difficult to get the credentials that you need to move up in the maritime industry. So, to get kids early and young thinking about what they're doing and to understand that their record really does matter, and that it would limit their job choices, is really important.

KELLY: Tell me more about the Youth Maritime Collaborative. How does it differ from the Experience Maritime program?
SCHERER: Well, Experience Maritime is a four-day, basically, maritime summer camp. It's an awareness program. Youth Maritime Collaborative came about a year and a half ago. The Port of Seattle was doing summer high school shoreside internships and they asked me to help pull some people together to create experiential events for these interns. When I started thinking about it, I was like, there are a few youth maritime educators out there. We should all pull together and pool our resources, then we all get a little publicity. We all get a little bit of face time in front of these kids and we help each other out. So that's what we did and it evolved into being called the Youth Maritime Collaborative.

Most students really don't know that the maritime industry is an option, even though we live in a geographically perfect maritime environment.

We started by being funded by the Port of Seattle. We started going and we got all these groups together and I was leading the group. My real job is to be a dean of a school, be the director of a program. So when I got busy and couldn't fully move things forward, then things started to die, and so we had a meeting. I said, "We need a coordinator. We need somebody to be coordinating this and I just can't do it." We actually made an agreement. I had the space in my building, so we ended up hiring a coordinator to begin to do that coordination. I'm still directing the high-level stuff of it and making negotiations with the Port of Seattle and all that, but we're looking for other funding to help move it forward because it's really doing well. Over the course of a year, we do one of the experiential events we do here at Seattle Maritime Academy. The first year we did it, we had 18 different stations for the kids to go through. We had around 130 kids, and around 40 adult volunteers. It was everything from line throwing to shooting off flares, and being in our full mission simulator. I used to work for NOAA, so I had NOAA charting and the NOAA science divers and the Office of Response and Restoration, which does oil spill response. We had all this really cool science and maritime stuff out on the pier that the students could go through.

The second year that we did it, we had more than 200 kids. We really bumped it up and had more kids and more stations. We just do it because it's the right thing to do. It's a "funnel" event to get people to know that these Youth Maritime Collaborative events are coming and then this coming year, the Youth Maritime Collaborative will have its own interns. We're in partnership with, like I mentioned, the Seattle Goodwill Youth Maritime program. They've started a program. Those students that are in the Youth Maritime program will be our interns next year. We will solicit industry to host high school interns, for them to be around the maritime industry on land just to see what it's like. We'll be recruiting host companies to do that. When they're in their internship, these experiential events will happen.

One of our partners is Salish Sea Expeditions. They'll take them on their boat. One of their boats is moored at Pac Fish [Pacific Fishermen] Shipyard. They do a barbecue and a tour of Pac Fish Shipyard and Elliott Bay Design Group, which is a naval architecture group, comes in and talks about naval architecture. Then they get to walk through the shipyard and actually see what they were just talking about…they're really bringing about that career connective learning. They get to go out on the Schooner Adventuress, which is a marine science tall ship. They go out for a three-hour sail and then there's a capstone program that's a three-day sail that we try to get people to go on because it really teaches them teamwork. It teaches them what it's like to be out at sea for two or three days, and to be around other people like that. I think kids in this generation are not really getting those experiences unless they're going to camp or something like that.

KELLY: So for a 14 or 15 or 16-year old who comes to the Experience Maritime event one summer, could he or she come back a year later and be an intern?
SCHERER: They could come to Experience Maritime and then the next year, they could potentially be an intern with a maritime company on land. They might be with CSR Marine



Students from Coastal Villages Region Fund (Western Alaska) practicing lookout duties in a liferaft in the Experience Maritime program.

Students gathered on the bow of Seattle Maritime Academy's *Maritime Instructor* for a safety briefing.



A student tests a survival suit at Seattle Maritime Academy.

or Pac Fish Shipyard or Elliott Bay Design Group as a shoreside high school intern.

KELLY: Other than perhaps seasickness, what could prevent a 16 or 17-year old from getting excited about a maritime career with that kind of experience?

SCHERER: Nothing. During Experience Maritime, the first three days are focused on going underway, but when we do the career exploration and then the education piece, we talk about the cross section of the maritime industry in the Pacific Northwest. We ask, "Okay, if you don't want to go to sea, you can go to Skagit Valley College and become a marine technician, which is basically like a ship's engineer on land. Go to South Seattle College and go to their Vigor welding program. It's a six-month program where you could start working in



a shipyard almost right away." We talk about the gamut [of opportunities]. There are different marine apprenticeship programs at South Seattle College, as well. You go to the marine electrician HVAC program, which is an apprenticeship, and you can write your own ticket. They're struggling for marine electronics technicians. We also are working with the Seattle School District on a summer skills center program that's going right now. It's a four-week program that has, I think, 20 kids this year. They had 24 last year. We're working for a Fall program and that would be a two-year program that will eventually become registered. We're hoping to make it into the first vessel operations pre-apprenticeship in the country.

With all of these programs, we're just trying to give them an awareness. There are two main things. One is, you don't have to get a bachelor's degree to be successful. There are all of these trades in the maritime industry that have a bunch of people that are about to retire, and there's upward mobility. It doesn't take that much education and you can be making a lot of money really quickly and have a very successful career. Or, you can get a bachelor's degree, and come back to the maritime industry because every maritime company needs HR, they need business development, they need finance people, they need project managers, they need everybody. [Many students] just don't know that [these opportunities] exist. The average age of a maritime employee in Washington is 55 years old. In the next 10 years, there are going to be mass retirements. Every trade is struggling right now, and that's not just in the maritime industry. Every trade is struggling. So it's a misnomer for this generation that's coming up to say, "There are no jobs." There are jobs sitting open, vacant, that are in the trades that are better than family living wage jobs.

KELLY: Have you been able to track the careers, the type of jobs that your certificate graduates are going into? What kind of work are they doing after they graduate?
SCHERER: They go to sea. They're actively working in the maritime industry. Many of our students go out on their internships and, if it's not a union shop, they get hired immediately. I know for two students who went out with Coastal Transportation last year…Coastal is a shipping, fishing, transportation company, they take supplies back and forth to Alaska for the fishing industry. The two students that went out with them last year—deck students—got offered jobs immediately after they finished their internships and they're now working for them. The folks that went to work on their internship with NOAA last year, they actually got hired, instead of working as interns, and they're both still working for NOAA. Last year, we had a guy who was an intern for Harley, and he's working for Harley. They typically get hired, unless it's a union shop.

KELLY: Sarah, our conversation went by very quickly. Anything you'd like to add either about the certificate programs or the youth outreach programs?
SCHERER: Just that being a part of Seattle Central College is actually super helpful because our students can use financial aid. They can use their GI bill, they can use worker retraining money, they can use scholarship funds. It's just like any other community college-type system where they can come in and get help with funding. It costs $9,000 to $10,000 for a little over a year program, and the students start making $45,000.00 to $75,000.00 right out of school. **MT**



STARTING 'EM YOUNG

SNAME members work to introduce kids to engineering as a creative activity that benefits society

BY PETER NOBLE, THALIA KRUGER, ROGER I. BASU, AND SUSAN SCURLOCK



Houston MECA students learning about engineering and technology.

In a paper titled "Developing An Engineering Identity In Early Childhood," published recently in the *American Journal of Engineering Education*, the authors describe the responses of a group of 3 to 7 year olds to the question "What do engineers do?" Some 300 children were asked this question, and the number one answer was "I don't know." The second most popular answer was "They drive a train." Thank you Reverend Awdry, author of the Thomas the Tank Engine stories.

While this may be amusing, it also should give pause to us engineering professionals. But of even greater concern is the current public perception of engineering, based largely on media reports and "green" organizations, as a grubby, polluting, and environmentally damaging activity, while science seems to be championed as pure and good. This view is supported by the inaccurate definition of engineering as the art or science of making practical application of the knowledge of pure sciences, such as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants.

But engineering is not the application of pure sciences. In fact, engineering often precedes science. One classic example is the fact that James Watt perfected the steam engine in 1775, which led directly to the Industrial Revolution, approximately 75 years before Kelvin and

STARTING 'EM YOUNG



The EIR program started small in 1998, when 14 schools participated in the program; today, some 200 schools across Ontario take advantage of the program.

Rankine discovered the science of thermodynamics which explained why heat engines work.

A better definition of engineering might be the process of inventing, innovating, designing, building, operating, researching, and improving structures; machines; tools; systems; materials; components; processes; solutions; and organizations. This is done for the benefit of society, using creativity; ingenuity; empirical evidence; practical knowledge; mathematics; economics; science; and social knowledge.

The reality is that, in the developed world, we live generally, safe, comfortable and rewarding lives due to the availability of technology. In the developing world, engineering and technology are bringing clean water, electricity, telecommunications, and other infrastructure, which are dramatically improving the overall progress of humanity, through reduction in infant mortality rates, increased life expectancy, and generally improved quality of life.

Perhaps Theodore von Kármán said it best: "Scientists discover the world that exists; engineers create the world that never was." And, as we all live in this engineered world, we must continue to develop talent to support society's ability to survive and prosper.

Program weakness

It has been recognized for some time now that science, technology, engineering, and math (STEM) are of critical importance to modern life, and STEM programs have been taught in schools for some time. One of the weaknesses in these programs has been a lack of teachers who understand and can teach the technology and engineering components of STEM.

STEM education has become a major focus of the National Academies in the U.S., stimulated largely because research has shown that, by 4th grade, students who have limited exposure to early STEM education are lacking key math and science skills and background knowledge. By grade 4, there is a decline in STEM interest and this decline has been linked to a lack of consistent focus in science content and literacy in the early grades; a lack of instructional methods that build on young children's curiosity to explore the world around them; and a lack of focus on science content literacy. Even with current programs designed to introduce, and engender excitement about, engineering in the early grades (K-2), using innovative teaching techniques, less than 10% of the instructional time is spent teaching science and considerably less on teaching engineering.

Some have recognized that this challenge may be addressed by linking engineering with literacy instruction, which is the primary instructional focus for this early education age group. Moreover, because engineering uses math and science to solve problems, a focus on engineering content can elicit young childrens' situational understanding of science and mathematics.

While SNAME is not yet involved in an organized way, a number of our individual members are active at a grassroots level. They are exploring, developing, and delivering support to programs that use engineering as a vehicle for student learning of the relationships between technology, science, and society, and generating student creativity and excitement. Of course, we in SNAME recognize that there can be nothing more creative and exciting than naval architecture, and marine and ocean engineering.

Ontario's Engineer-In-Residence

The importance of the central role that STEM plays in modern life is acknowledged by the relevant educational authorities in Canada. And, although Canada performs reasonably well on international standardized tests, there was a perception about 20 years ago that there was waning interest in the so-called STEM subjects, at least in the province of Ontario. In regard to engineering, this was partly attributed to the limited presence of the engineering profession in classrooms to the extent that students entering engineering programs in colleges and universities had a very limited understanding of engineering.

In Ontario, the province of Canada with the largest population, these shortcomings became evident to Professional Engineers Ontario (PEO). With some 85,000 members, PEO regulates the practice of professional engineering in Ontario and is responsible for the licensing of professional engineers in the province.

Among its several functions, PEO's education committee focuses on pre-university student and educator outreach and curriculum issues involving engineering. The committee also administers the Engineer-in-Residence program (EIR). The day-to-day running of the EIR program is the responsibility of a non-profit, Engineers-Without-Borders (EWB). EWB also provides orientation and training for EIRs. The EIR program started small in 1998, when 14 schools participated in the







Co-author Thalia Thalía Krüger with MECA 1st and 2nd grade students.

program; today, some 200 schools across Ontario take advantage of the program, and there are plans to steadily increase the reach of the program. In general, each participating school has an EIR, who is a volunteer professional engineer. Both working and retired professional engineers take part in the program. The program has some limited funds available to support EIR activities. Where possible, resources within schools are used for EIR classroom activities.

The goals of the EIR program are to create partnerships and engage with interested parties such as school boards, PEO members and chapters, and local communities. Ultimately, the objective is to promote a better understanding in students of engineering and the engineering professions. The EIR typically works with a teacher in a school and participates in classroom activities associated with relevant elements of the curriculum. The stated goals by Ontario's educational authorities for science and technology education for grades 1 through 8 are to relate science and technology to society and the environment; to develop the skills, strategies, and habits of mind required for scientific inquiry and technological problem solving; and to understand the basic concepts of science and technology.

In this regard, importance is placed on the context within which engineering takes place. The approach adopted for introducing engineering and technology concepts to students varies depending on a number of factors. Among them are age of the students, the teacher's interpretation of curriculum requirements, the EIR's interests and capabilities, and the "personality" of the class, which can vary considerably. The EIR and the primary contact teacher work out what



makes sense based on the school's needs and the engineer's schedule and strengths.

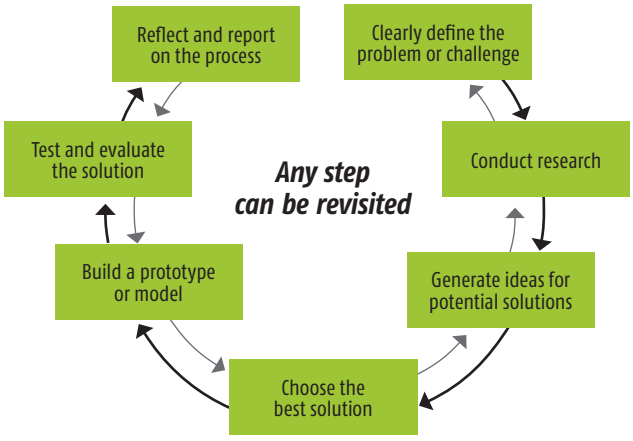
The mode of interaction between EIRs and the classroom can include hands-on activities, laboratory demonstrations, individual and team projects, and presentations on engineering and what it means to be an engineer. The interaction can also include assistance by the EIR on special projects, field trips to places of work, career advice, and helping in forging links between the school and industry.

There are several challenges faced by EIRs in designing meaningful interaction with students that keeps them engaged. It is necessary to pitch the material presented by the EIR at the right level such that the student remains engaged and also learns. Lectures are necessary, but these have to be designed with care. There is certain information that has to be transmitted to students and, sometimes, a lecture is the only effective way. Therefore, it is important to vary the content and the method of delivering information. Judiciously selected videos relevant to the topic are popular. It is important that the EIR has a list of questions to ask the class at regular intervals to keep students engaged and also to spur dialogue.

Almost always, a central element of the interaction of students with their EIR is a hands-on project in which students are required to design and build a structure, mechanism, or other engineering artifact. The degree of success of these efforts varies, as they do in the real world. The program places emphasis on the problem solving aspect of engineering, as illustrated in Figure 1.

Hence, problems are presented to students such that alternative solutions are possible and students are encouraged to generate ideas and select one for further investigation that typically requires the design, building, and testing of a simple engineering system. Problems are designed to lend themselves to alternative solutions that can be investigated in a classroom setting. Of course, some solutions are more effective than others and, in this regard, the "post mortem" phase is often part of the project, where students are urged to identify faults in their solutions and how to improve the design.

Figure 1: Steps in the Design Process



From The Ontario Curriculum, Grades 9–10, Ontario Ministry of Education, 2009

They quickly engaged the kids in the discussion when they told them about their childhood experiences and how they became involved in engineering.

An example of a typical project, in this case with grade 3 students, is a simple bridge structure. Students are required to build a bridge to a specification given simple materials. The only requirement is that the bridge should span a certain distance and carry a given weight. Some of the attempts produce impractical designs often because the specification is incomplete (a lesson for the EIR). Some projects are more constrained and designed to demonstrate an important engineering principle, such as conversion of one form of energy to another.

STEM by stealth

Primary Engineer is a program similar to the EIR initiative, and is well established in the U.K., having started in 2005. Primary Engineer uses a "STEM by stealth" educational approach to bringing engineering and engineers into primary classrooms and curricula. The program—used in primary schools in the U.K., which equate to elementary schools in the U.S.—inspires children, students, and teachers through continued professional development, whole class project work, competitions, and exhibitions.

The aim is to first develop the skills and confidence in teachers, and then extend from this secure foundation into the classroom. Teacher training and classroom-based, curriculum-mapped activities have ensured that the program engages students and teachers. The program has a national reach and invites engineers to host training days so that schoolteachers can see what an engineering environment looks like. Engineers also are invited to join teachers in the training to help them through the course. Finally, as part of the class, engineers provide context for the project, linking it to engineering and to the real world.

Students between the ages of 3 and 18 are asked, "If you were an engineer, what would you do?" The students are required to interview engineers—not just about their jobs and



MECA panelists and organizers, left to right: Patricia Vega, Barbara Thompson, co-author Peter Noble, JoAnn Meyer, Esen Erdemir, co-author Thalia Kruger, Clena Abuan, and Ed Marotta.

problem solving, but also about "problem finding," and the role of creativity in engineering. The outcome has been that, in 2018, more than 37,000 students answered the question, interviewed an engineer, found a problem, drew a solution to it, and wrote a letter explaining why engineers should build it.

The entries were then judged by more than 300 engineers on grading days around the country, and this is where the children began to inspire the engineers. With simplicity and creativity, and untethered by technical restraints, the inventions address the real needs of family, the community, and the world. The children see engineering as a way to make people's lives better, and to make the world safer and more environmentally friendly.

The program depends on the support of industry and engineers who are willing to give their time and experience to inspiring future generations of children. At the end of the day, if those children don't pursue a career in engineering, they at least will know what it is and what it can achieve.

Summer camp

Every year, in Houston, TX, the Multicultural Education and Counseling though Arts (MECA) organizes the Sunburst Summer Camp. It is an intensive seven-week program that provides youth with hands-on experience in arts, literature, and science.

This year, a pilot program was developed to encourage MECA students to explore careers in engineering. The students verified that both art and engineering have a common foundation in creativity. Real engineers JoAnn Meyer (a petroleum engineer and principal at Previser), co-author Thalia Kruger (manager Global Offshore at ABS), and Esen Erdemir (subsea structures engineering supervisor at TechnipFMC), devoted one to two hours weekly to talk to the kids about engineering fields. The goal was to help broaden the kids' opportunities in life without leaving aside their love for art.

The 2018 introduction to engineering program was divided into three levels. The objective of the kinder through 3rd grade level is to develop curiosity about engineering-related careers. The approach is to provide examples of all of the daily activities that would not happen without engineers. Engineers build buildings, highways, automobiles, ships, airplanes, and machines used to manufacture products.

The objective of the 4th through 6th grade level is to introduce students to the various career paths that are available with engineering degrees, and to increase their understanding of what engineers do. The approach is to provide examples of well-known companies and describe how engineers are part of those companies.

The objective of the 7th through 9th grade level is to encourage students to consider engineering as a career path, if they enjoy science and math, and to increase awareness of the classes that are important to take in high school if they want to become engineers. The approach is to discuss some of the world's biggest challenges and how engineers can be part of the solutions that make our world better.

As the 2018 summer camp ended, the impact of the program was evident with the kids entering the session with little or no knowledge about careers in engineering and ending the session relating to technical fields. A set of slides was prepared for each age group as an introduction. After the short introduction, the kids were divided into two groups: designers and builders. Designers were given paper and pens/markers, while builders were given wooden sticks, glue, and other craft materials.

In one session, a first grader started crying after he thought it would be impossible to build the T-shaped building he had designed. It took a little of imagination, but he was able to build the T building in paper. His reaction after drying his tears was, "I want to be an engineer."

Another first grader was very happy about being able to first design and then build a space rocket. A second grade



girl, in the designers group, stated that she wanted to become a dress designer, so she wouldn't draw any machine but a dress. After praising her work, the instructor suggested that what she drew looked like an astronaut suit. The girl felt included and proceeded to paint the suit with a NASA logo.

A third grader was completely absorbed in taking care of her stuffed animal. When a suggestion was made about a ship being able to transport toys, she proceeded, with enthusiasm, to draw an exact copy of a ship model carrying her pet on it.

To conclude the program, for the final session, the instructors invited experienced engineers, from diverse backgrounds and skilled in a wide range of engineering disciplines, to talk about their careers in a panel format. For some of them, it was their first experience addressing such an audience. They quickly engaged the kids in the discussion when they told them about their childhood experiences and how they became involved in engineering. The panel was moderated by Thalia Kruger and JoAnn Meyer, and the panelists were Patricia Vega, Barbara Thompson, Peter Noble, Esen Erdemir, Clena Abuan, and Ed Marotta.

TEAMS

We've examined here just three examples of the many areas and programs in which individual SNAME members, at a grassroots level, are volunteering to spread the good news of why young people should think about careers in engineering and technology.

Recent studies of current STEM programs are showing some lack of success. The original idea of STEM education is accepted as a good concept to promote understanding of the importance of technology and engineering in school age children. However, our current school system is not great at teaching the analytical skills in math and science and has almost no ability in it's teaching staff to teach the creative skills required for technology and engineering. The one slightly positive thing is that a lot of what is taught as science and created for science fairs is actually technology, hidden under the name of science.

We propose a new concept to overcome some of the challenges that have emerged with STEM programs. The one school subject that drives the creative side of young children is art, and as we have seen from the MECA program that creativity is at the intersection of art and engineering. Further, both the Engineer-in-Residence program and the Primary Engineer program examined here use engineers and engineering to assist teaching staff with STEM activities.

Perhaps a new program that is built around these realities might find traction: TEAMS…for technology, engineering, art, math, and science. TEAMS would lead with the creative subjects of technology and engineering and art, while the analytical skills of math and science would support the creative side.

The words of Carl Mitcham, philosopher and professor of liberal arts and international studies at the Colorado School of Mines, summarize why the core activities of engineering—design and invention—should be exciting to anyone who exhibits a creative streak: "Design and invention cause things to come into existence from ideas; they make the world conform to thought; whereas science, by deriving ideas from observation and analysis, makes thought conform to existence."

Because we live on a planet that might be better named planet Ocean than planet Earth, as 70% of the surface is covered by seas, there is a particular need for creative people in the fields of naval architecture and marine and ocean engineering. Most *(mt)* readers already understand there are few things more exciting than seeing a vessel one has designed set sail on the oceans of the world. It is our responsibility to share that excitement by engaging with young students. **MT**

Peter Noble *is a naval architect, and a marine and ocean engineer with a wide range of expertise and experience in the marine and offshore industries.* ***Thalía Krüger*** *is manager, Global Offshore at Houston-based ABS.* ***Roger I. Basu*** *is a structural engineer with more than 45 years of experience and a Professional Engineer registered in the Province of Ontario.* ***Susan Scurlock*** *is chief executive and founder of Primary Engineer, in the U.K.*

Deeper Dive

For more information on the topics explored in this article, check out the following resources.

American Journal of Engineering Education, December 2015: "Developing An Engineering Identity In Early Childhood"

National Academies Press: *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics* (2011).

STEM Smart Brief: *Engineering: Emphasizing the "E" in STEM Education*; http://www.successfulstemeducation.org/resources/engineering-emphasizing-"e"-stem-education

National Research Council (2009): Engineering in K–12 education: Understanding the status and improving the prospects. The National Academies Press.

National Research Council (2012): *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.*

Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. The National Academies Press.



VESSEL REPORT: MARAD NSMV

BY EUGENE VAN RYNBACH

The four-year training programs at the six State Maritime Academies (SMA) represent one of the primary methods of training licensed merchant marine officers in the United States. The SMAs are located in Maine, Massachusetts, New York, Texas, California, and Michigan (Great Lakes). All are part of their respective state university systems and offer accredited bachelor's degrees and a United States Coast Guard-issued Third Mate or Third Engineer license for those enrolled in the license programs. Besides attending the typical university classrooms and laboratories, what is unusual about the SMAs is that all have their own training ship. Each cadet needs approximately one year of sea time onboard a ship or equivalent time to be eligible to take the license examination. This is typically done over three or four sea terms during the cadet's years at the SMA. Besides sea time on the SMA's own ship, cadets frequently also work on ships or boats in actual service to obtain real-world experience. The United States Merchant Marine Academy, which has a small training ship, has opted for its cadets to gain sea time by working on large commercial ships in service.

Learning on a training ship has many educational advantages for the mariners in training. For gaining the practical knowledge necessary to navigate and operate a ship, simulation and ashore training can't make up for the actual feel and real-life experience of sailing onboard an operating ship. Training cadets onboard an operating ship enables the instructors to sail with and attest to their competencies. The training ships normally tie up at the SMAs, so they also are available year-round for onboard training. Some cadets even live on the ships to get a taste of shipboard living and for familiarization before going to sea.

The current SMA training ships were all built for other purposes and later converted to training ships. All are getting up in age. The oldest one, *Empire State VI* at NY Maritime College, was originally constructed as a cargo ship in the early 1960s and has outdated steam propulsion. The newer training ships, at Cal Maritime and Maine Maritime, will soon be 30 years old. Much of the equipment on these ships is obsolete and different from equipment on ships being built today. The United States Maritime Administration (MARAD) owns and funds the training ships and has embarked on a program to build

> Simulation and ashore training can't make up for the actual feel and real-life experience of sailing onboard an operating ship.

replacement training ships able to offer training with modern propulsion systems and navigation equipment, while also outfitted with improved berthing and equipped with flexible and fully wired classrooms, workshops, and laboratories. Funding is in place to replace first the oldest training ship, *Empire State VI*, followed by the other training ships if additional funding is approved.

Other missions

Besides functioning as training ships, the U.S. government has found them to be well suited as available assets for government response to humanitarian and disaster crises in coastal and port areas. Over the last 15 years, the training ships have been called into this service multiple times, including for major hurricanes Katrina, Sandy, Harvey, Maria, and others. The training ships have large accommodation spaces, public spaces, and classroom spaces that can house, feed, and provide working space for large numbers of response personnel, and they are readily available because they are idle much of the year. These factors make them highly valuable for such missions.

This ability to merge two primary missions, training and emergency response, into one vessel is a critical design feature that MARAD required to be incorporated into the new training ships. It provides the reason for their class name, the National Security Multi-Mission Vessel, or NSMV for short, with the emphasis on multi-mission capability. Up to five NSMVs will be needed to replace all the SMA ocean-going training ships. The Great Lakes SMA has a need for a smaller vessel, better suited for the Great Lakes.

My company, Herbert Engineering Corp. (HEC), was contracted by MARAD to prepare the NSMV design. Several rounds of design effort have been completed. In 2015, a concept level design was prepared, and in early 2017 the phase 3 design was completed. This consisted of approximately 60 deliverables covering the full range of ship design, including basic engineering; key system and structure drawings; full ship finite element structural analysis; intact and damage stability analysis; hull lines optimization and model testing; and a building specification. The package is expected to be sufficient for shipyards to prepare bids to build NSMV as the project enters the acquisition phase, starting in the near term, followed soon thereafter with the construction of the first NSMV. It is hoped that NY Maritime College will have the first NSMV in time for the summer sea term in 2022.

HEC's focus during the development of the NSMV design was on creating a lean vessel that is able to meet key requirements in a cost effective way, because funding for all such programs is necessarily limited. The design is based on commonly available commercial equipment and machinery and use of international standards and requirements to promote using off-the-shelf design and machinery.

Training facilities

The primary mission, year in and year out, of NSMV will be training future merchant marine officers. To that end, there was great focus during the design process to provide a wide range of teaching and training facilities onboard the ship. Visits were made to three of the existing training ships—at Cal Maritime, Mass Maritime, and NY Maritime—so the HEC designers could see first-hand existing training ships and talk to the educators at the SMAs. The SMAs have developed many new and innovative training facilities and new programs onboard the existing ships that were interesting to learn about, plus the staffs had many ideas on what more could be added to the new ships and offered useful suggestions on what should be avoided. Because the NSMV is an all-new design and not subject to the many limitations encountered when converting an existing ship, NSMV can incorporate more and better capable training facilities than any of the existing training ships. Some of NSMV's key training facilities and capabilities are as follows.

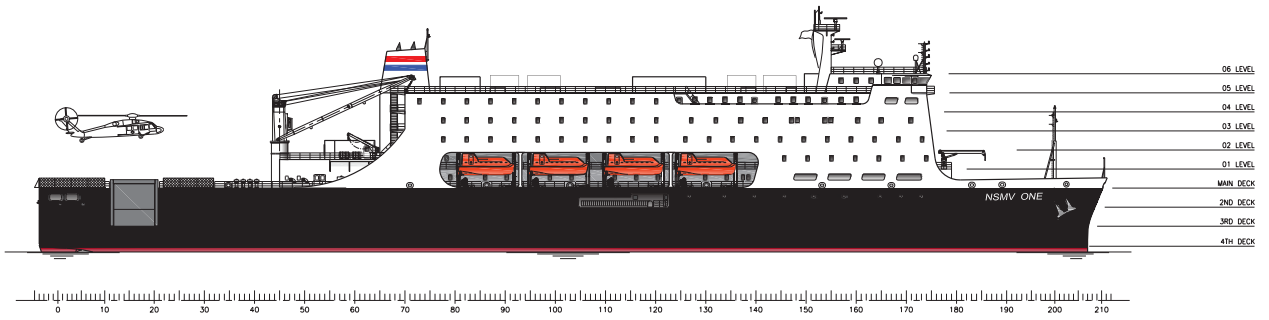
Classrooms. There are to be eight dedicated classrooms, ranging in size from large classrooms with 60 cadets to smaller, more informal classrooms for 30 cadets. Six of the classrooms are adjacent to each other and the faculty offices on the third deck, forming the core teaching area. Two more of the larger classrooms are on the main deck, where



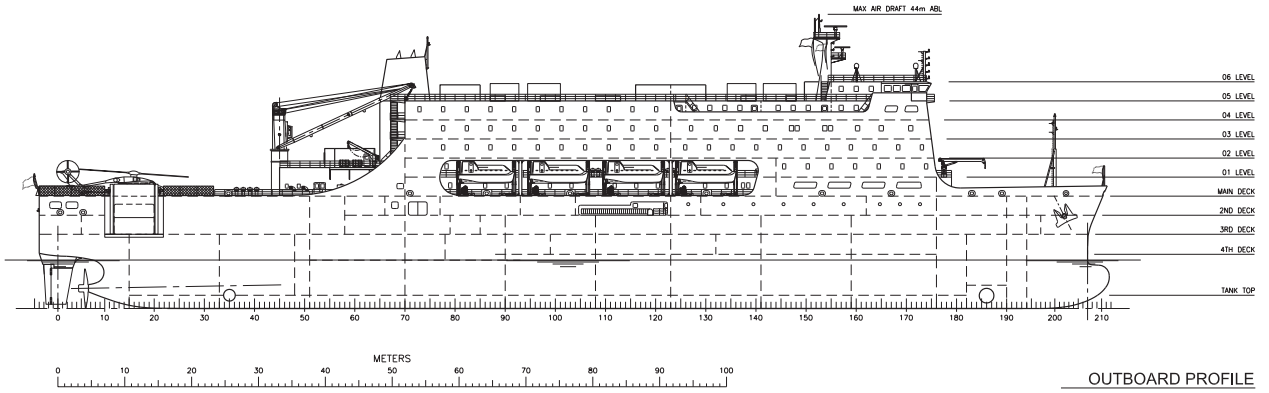
The laboratories on the fourth deck of the NSMV contain training equipment and simulators that teach cadets the details of how marine machinery and systems operate.

SPECIFICATIONS: NSMV

HULL PARTICULARS	LENGTH OVERALL	159.85 m (524 ft. 5 in.)
	BEAM	27.0 m (88 ft. 7 in.)
	DRAFT	6.5 m (21 ft. 4 in.) design draft
	DESIGN SERVICE SPEED	Full Speed: 18 kts with 15% sea margin Cruising Speed: 12 knots
CLASS	CLASS NOTATIONS	ABS, +A1, E, Training Ship, +AMS, +ACC, SPS, UWILD, CRC, CPS, ENVIRO, GP, HELIDK
PROPULSION	POWER SOURCE	Diesel electric
	PROPULSION ENGINES	4 x diesel generators Total installed power: 15,680 kW
	PROPELLERS	1 propeller, fixed pitch
	RUDDERS	1 flap type rudder on centerline
	FUEL	Single fuel—marine gas oil, maximum sulfur content 0.1%
MANEUVERABILITY	THRUSTERS	Bow thruster: retractable combi type—tunnel thruster in up position, azimuthing thruster in down position, "Take Home" propulsor, 1450 kW Stern thruster: tunnel type, 890 kW
CONSUMPTION	FUEL CONSUMPTION	60 tons/day at 18 knots, 26 tons/day at 12 knots
	FRESH WATER (INCLUDING SANITARY WATER)	35 gal./day per person for 700 = 93 tons + 5 tons ship service FW = 98 tons/day
ENDURANCE	FUEL RANGE	Approximately 11,000 nm range at 18 knots design speed with 10% remaining fuel
	FOOD AND STORES	60 days food storage for 700 persons 297 m^2 (3,200 ft^2) reefer provisions 240 m^2 (2,580 ft^2) dry provisions
ACCOMMODATION SIZE	TRAINING MODE	100 officer, crew, faculty, and staff plus 600 cadets
	OFFICER CLASS STATEROOMS	29 single state rooms with private toilet/shower unit
	CREW CLASS STATEROOMS	34 single state rooms with private toilet/shower unit
	FACULTY AND STAFF CLASS STATEROOMS	37 single state rooms with private toilet/shower unit
	CADETS	384 cadets in 4 person staterooms with private toilet/shower unit 216 cadets in larger berthing areas—18 to 30 cadets each
	SURGE MODE	60 additional persons by doubling up some faculty, staff, and crew cabins. Up to 760 onboard in surge mode
MACHINERY	MAIN MACHINERY SPACES	Two separate main machinery spaces in separate fire zones with dividing water-tight bulkhead. No more than one sliding watertight door connects them
	AUXILIARY MACHINERY SPACES	Separate auxiliary machinery space under each accommodation zone for providing services to that zone
	PROPULSION MOTORS	2 x 4,500 kW propulsion motors. Motors in separate watertight compartments for redundancy
	ELECTRIC POWER	6,600 V main power generation, 440 V ship service electric power, 120 V lighting and accommodations
CLASSROOMS, TRAINING SPACES, SPECIAL PURPOSE AREAS	GENERAL CLASSROOMS	2 classrooms x 60 persons 2 x 45 persons 4 x 30 persons
	DECK AND ENGINE DEPARTMENT TRAINING SPACES	Large training spaces for deck and engine cadets Navigation lab below bridge level, and multiple workshops and laboratories on lower decks
	TRAINING BRIDGE	Training bridge below the navigation bridge
	MULTI-PURPOSE SPACE	Large auditorium space for at least 200
CARGO/MODULAR STORAGE SPACE	RORO DECK	RoRo space aft with length of about 40 m (130 ft.), width inside framing of 24 m (80 ft.), clear height of at least 4.7 m (15.3 ft.). Usable deck area is about 1,000 m^2 (10,700 ft^2). Suitable for about 10 x 40 ft. trailers with 26 autos or about 49 autos/light trucks
	CONTAINER STOWAGE	Open main deck area aft of the deckhouse and on top of the multi-purpose space. Total container capacity about 64 TEU for two high
	CRANE	1 x jib boom type with 35 MT SWL x 24 m outreach
	RORO RAMP	20 ft. wide watertight wide side ramp with 40 ton capacity

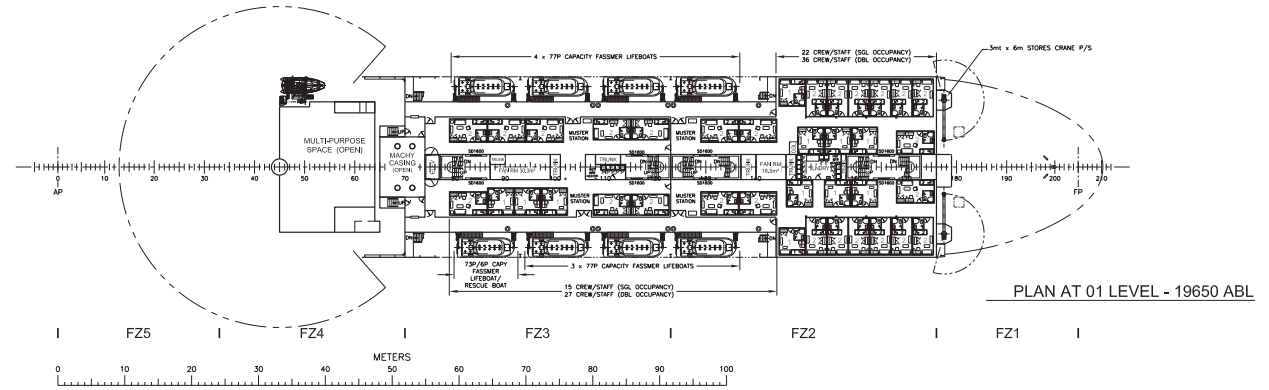


WATERLINE PROFILE

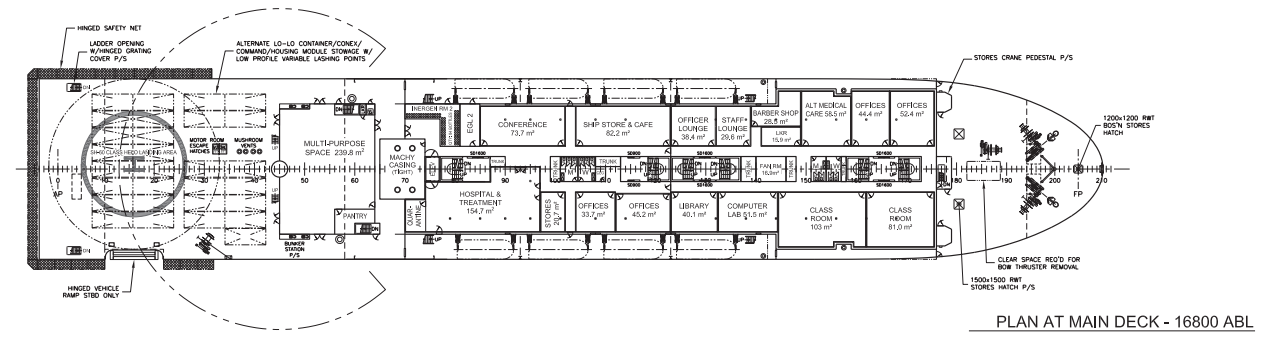


OUTBOARD PROFILE

HEC Herbert Engineering Corp. PROJECT FILE: 2015-017-03	SCALE: 1:500 SCOPE: -	United States Maritime Administration	NSMV - PHASE 3 GENERAL ARRANGEMENT	2015-017-03-01 SHEET 2 OF 8 REV 1



PLAN AT 01 LEVEL - 19650 ABL



PLAN AT MAIN DECK - 16800 ABL

HEC Herbert Engineering Corp. PROJECT FILE: 2015-017-03	SCALE: 1:500 SCOPE: -	United States Maritime Administration	NSMV - PHASE 3 GENERAL ARRANGEMENT	2015-017-03-01 SHEET 6 OF 8 REV 1



A separate training bridge, located below the existing bridge, will have a full suite of bridge electronics, including radar displays and communication equipment. This equipment will operate in the display mode during training, but it can be activated in case of damage or casualty to the primary bridge when the training bridge can take over control of the vessel.

they can also function as assembly and meeting areas during humanitarian assistance / disaster response (HA/DR) missions. All classrooms have large video monitors and are connected into the vessel's digital network.

Training bridge. Unique to the dedicated training ships is a separate training bridge below the existing bridge. This concept was previously incorporated in some of the existing training ships, but the NSMV will be the first one with the training bridge just below the primary bridge with comparable forward visibility. There will be a full suite of bridge electronics in the training bridge, including radar displays, DGPS, speed logs, ECDIS chart displays, and communication equipment so the cadets can follow along with the real navigation of the ship, but not interfere with the working bridge. This equipment will operate in the display mode during training, but it can be activated in case of damage or casualty to the primary bridge when the training bridge can take over control of the vessel.

Navigation lab. A navigation lab is located aft of the training bridge. This will have multiple workstations with video monitors for teaching cadets the principles of navigation through demonstration and simulation. Each cadet will have his or her own workstation for hands-on learning.

Deck training. A deck training space for learning marlinspike seamanship is located in the bow area.

Multi-purpose space. A large multi-purpose space that can seat up to 200 or more is located on the main deck aft. It is useful for large lectures, meetings, group assemblies, and port and visitor receptions.

Workshops and labs. Four cadet workshops and four cadet laboratories are located on the fourth deck. The workshops have workbenches with power and hand tools and other workshop equipment. They provide a place for the cadets to gain experience working with tools, making repairs, and building their own projects. They will need this knowledge once they become responsible for keeping their own ships operating 24 hours a day. The nearby laboratories contain training equipment and simulators that provide cadets with an opportunity to learn the details of how modern marine machinery and systems operate.

Dual engine rooms. There are two separate engine rooms to provide the necessary redundancy to ensure propulsion is available in case of a casualty in one. The fact there are two separate engine rooms provides a good training opportunity to the cadets because, while on training cruises, the ships frequently operate at approximately 12 knots, requiring power from only one engine room. They operate at slower speeds because time at sea is of greater importance than arriving quickly at a destination. In the idle engine room, engines and machinery can be turned on and off

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TOTE Maritime



The design of the NSMV features a helicopter landing area on the open aft deck.

for training purposes and even opened for inspection of the internals. There is less noise in the idle engine room without the constantly running engines, making for a better training environment. Each engine room has its own control room, allowing the idle engine room one to be used for training without the danger of cadets touching something they should not and affecting the ship's operation.

Computer labs/library/study spaces. Because NSMV will be a university teaching facility, it also will be fully equipped with an academic library, computer lab, and study rooms so that cadets can work on homework and research projects like other students.

Digital network. The NSMV is planned to be fully wired to each cabin, cadet bunk space, training spaces, public spaces, and work spaces with a full ship LAN and Wi-Fi networks. Cell phone antenna repeaters provide cell service throughout the accommodation spaces while in port. Cyber resistance will be built into the system.

Propulsion system

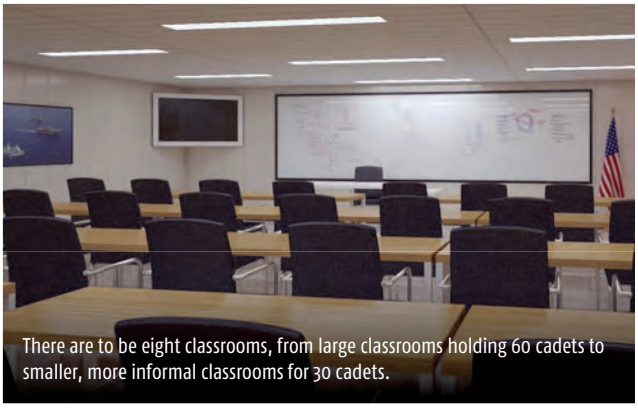
One of the key items to be resolved during the NSMV design was the propulsion system. Modern passenger ships normally have diesel electric power, useful because of the large ship service electric loads resulting from the large number of persons onboard. Diesel electric power also enables optimization of the number of engines online to suit a wide range of operating speeds. These same requirements also apply to NSMV, so the initial decision was made to adopt an integrated electric drive propulsion system with medium-speed diesel engines as prime movers, similar to cruise ships. These offer low initial cost, relatively small size, and good fuel efficiency. This met with some resistance from the SMAs, who are looking at the training aspects of the vessel as well as efficient operation. However, it was felt that alternative propulsion methods such as liquefied natural gas fuel, steam turbines, gas turbines, or low-speed diesels would significantly increase the cost of construction, and in some cases significantly raise fuel consumption. Furthermore, low-speed diesel is not well suited for electric drive, and it was believed training was available on these alternate propulsion systems using simulators or shoreside installations.

Another issue was whether to provide a steam system. It was decided against this for several reasons. One, the use of only distillate fuel meant there was no need to heat fuel, so no need for steam in the summer. Two, the efficient medium-speed diesel engines produce little exhaust heat to create steam. And three, accommodation heating

NSMV Design Team

The author's company, Herbert Engineering Corp., collaborated with several other companies to provide the full range of design capability needed for a full ship design. Key contributors were as follows:

- Herbert Engineering, project lead and lead on arrangement, structure, systems, machinery, stability, and regulatory compliance design. Assistance was received from Carl Setterstrom, consultant naval architect
- Jamestown Metal for galley and mess design, and training space and cabin layout
- SPAR Associates for cost estimation
- SSPA, Sweden, for hull lines optimization, model testing, and propeller design
- VT Group for IT infrastructure design
- Bruce S. Rosenblatt & Associates for accommodation piping systems and machinery space arrangements.



There are to be eight classrooms, from large classrooms holding 60 cadets to smaller, more informal classrooms for 30 cadets.

can be done using hot water from the engine cooling system, so there was no need for steam in the winter, either.

Key design features

Fulfilling the requirements to be both a training ship and a HA/DR ship required a lot of design decisions and tradeoffs. One key requirement was that NSMV should be fully compliant with safety regulations and requirements for a ship carrying up to 760 persons, both international regulations and United States Coast Guard regulations and ABS class Rules. This was a goal of the design even though, as a U.S. government-owned vessel documented as a Public Nautical School Ship, there was no legal requirement to meet the requirements of Safety of Life at Sea. It was determined the most appropriate safety regime for this type of vessel is the International Maritime Organization special purpose ship (SPS) code, noting that the SPS code is specifically intended to apply to maritime training ships.

The ships were designed to fit within the pier length and draft restrictions at the five SMAs and operate at no more than 25 ft. draft for access to smaller and less developed ports in support of HA/DR missions. This resulted in a length of less than 167 m (550 ft.).

It was a design goal for the ships to be efficient and economical to operate as well as to be environmentally friendly. The following features helped meet that goal: one, full time operation on clean burning, low-sulfur fuel; two, use of engine waste heat for accommodation heating; three, efficient LED lighting; four, hull lines optimized for low propulsion power; and five, ABS Class Notations ENVIRO and Green Passport, which indicate they are built to higher than normal environmental standards.

Berthing is provided for 700 persons in normal training ship mode, with 600 cadets and 100 non-cadets. Non-cadets consist of vessel officers and crew and SMA administrators, faculty, and staff. As an important quality of life feature, all 100 non-cadets have private cabins with private toilet and shower facilities. During HA/DR missions, the number of persons onboard can be increased by 60, to a total of 760. This requirement is met by installing two high berths in some of the non-cadet cabins, so while these normally accommodate one person, in surge periods they can accommodate two persons. NSMV has lifesaving equipment for the full complement of up to 760 persons.

Redundancy is provided as required by safety regulations and to continue essential services in case of a fire or flooding casualty in any one area. Safe return to port is possible even in case of loss of the main propulsion system, up to and including the main shaft and propeller. This is achieved by use of a drop down azimuthing bow thruster that can propel the ship at speeds over 6 knots. The bow and stern thruster together with the flap type rudder also enable NSMV to maneuver and moor without tugs. This is considered useful for HA/DR missions when ports may be disrupted by a crisis, and this capability reduces vessel operating costs during normal cruises.

HA/DR mission capability includes transport of general cargo, containers, vehicles, and trailers on the aft open deck area and in the enclosed RoRo space below that. A cargo crane, also useful for training, and a RoRo side ramp are provided to make the vessel self-unloading. Larger medical facilities than required for a training ship are provided and these can be easily expanded, including loading of medical modules on deck and in RoRo spaces with utility hookups provided. Ability to land helicopters, a key HA/DR mission requirement, was met by making the open aft deck also a helicopter landing area. The landing area was designed to commercial standards and is designed to land up to an SH-60 Seahawk helicopter. It is for helicopter landing only and there are no refueling or maintenance facilities provided. It was considered to include capability for landing a V-22 Osprey, but that would require significant reinforcement of the deck and special heat resistant materials, so it is not currently a requirement. **MT**

Eugene van Rynbach *is vice president of Herbert Engineering Corp.*

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Ultimate Strength Assessment of Hull Girder under Cyclic Bending Based on Smith's Method

BY HU-WEI CUI* AND PING YANG*†

*School of Transportation, Wuhan University of Technology, Wuhan, China
†Key Laboratory of High Performance Ship Technology (Wuhan University of Technology), Ministry of Education, Wuhan, China

PUBLISHED IN THE JUNE 2018 *JOURNAL OF SHIP RESEARCH*

Ultimate strength is a critical and fundamental consideration in the design of ship and offshore structures. Accurate assessment of the (residual) ultimate strength of a ship hull is important not only for the initial design, but also for the operation, maintenance, repair, and even for disaster management, rescue, and salvage assessment of the ship hulls. In fact, under ocean wave conditions, the hull girder is likely to withstand extreme cyclic bending. In this article, a simplified method based on Smith's method is proposed to assess the ultimate strength of the ship hulls under extreme cyclic bending. To obtain the nonlinear average stress–average strain relationship (σ–e curve) of the basic structural element (consisting of a stiffener with its attaching plating) under cyclic in-plane compression and tension, systematic calculations are carried out by using a combination of the Beam–Column analysis and the nonlinear finite element method (NLFEM). By introducing the cyclic σ–e curves of basic structural elements to a simplified calculation program, which is developed by the authors and based on Smith's method, the ultimate strength of hull girders exposed to extreme cyclic bending is subsequently determined. The ultimate strength of three box girder models and an actual ship are obtained under cyclic bending by using the authors' developed procedures including the simplified calculation program and are compared with the corresponding results from NLFEM calculations and also the box girder experiments.

The Low-Noise Optimization of a SWATH Ship's Structures Based on the Three-Dimensional Sono-Elasticity of Ships

BY MINGSONG ZOU*†, CHANGGANG LIN*, LIBO QI*†, AND SHUXIAO LIU*

*China Ship Scientific Research Center, Wuxi 214082, China
†National Key Laboratory on Ship Vibration and Noise, Wuxi 214082, China

PUBLISHED IN THE JUNE 2018 *JOURNAL OF SHIP RESEARCH*

Basic equations and numerical methods are presented for the three-dimensional sono-elasticity theory of ships in shallow sea Pekeris acoustic waveguide environment. The corresponding software three-dimensional hydroelastic analysis of floating and traveling structures-Acoustic developed based on this theory is used for low noise optimization design of the strut structures of a 1500-ton small waterplane area twin hull (SWATH) ship. When the SWATH ship was moored in waves and laying down instruments for ocean survey, it was observed that the waves continuously beat the vertical side walls of the struts, resulting in structural vibration and acoustic radiation in the frequency band below 100 Hz. This is a new phenomenon that the hydroelastic response of a local structure disturbs ocean survey performance. This phenomenon is not good for the performance of underwater acoustic equipment because it increases the background noise in the vicinity of the SWATH ship. This problem needs a low-cost and feasible solution. The mechanism of this phenomenon is first discussed by means of a sono-elastic analysis. After a series of low-noise design calculations for the strut structures, a design of optimal acoustic performance is obtained with only a small increase in the structure weight. Some suggestions on engineering design for solving such problems are also put forward.



Investigation on the Effect of Thermo-Mechanical Tensioning on Weld Induced Out-of-Plane Distortions

BY AMITH GADAGI, N. R. MANDAL, DEBABRATA PODDER, AND SHARAT KUMAR

Indian Institute of Technology Kharagpur, Kharagpur, India

PUBLISHED IN THE MAY 2018 *JOURNAL OF SHIP PRODUCTION AND DESIGN*

Fabrication of ship structures involving welding of thin plates, poses a real challenge in limiting the out-of-plane distortion due to buckling. In this study, the effect of thermo-mechanical tensioning (TMT) on minimizing out-of-plane distortion due to buckling in fabrication of stiffened panels has been investigated through experimental and numerical studies. Experiments were conducted using 3–mm-thick plates. The pretensioning of the plates was done along the stiffener welding lines using the shrinkage forces of the tensioning lugs. The lug width was decided based on the possible width of the tensile stress zone due to the welding of stiffener. The tensioning lugs were heated to a temperature so that the plastic deformation of the lugs are minimized thereby required tensioning of the plate could be achieved. Through the implementation of TMT, a noticeable reduction in the out-of-plane distortions were observed. The influence of the sequence of lug removal on the buckling distortions was studied numerically. Fairly good agreement was obtained between experimental and numerical results. The process of TMT was found to be quite effective as an active in-process distortion mitigation technique for fabrication of thin stiffened panels.

Balancing a Destroyer on a Wave for Strength and Stability

BY DOUG PERRAULT

Defence Research and Development Canada Atlantic Research Centre – Warship Performance, Dartmouth, Nova Scotia, Canada

PUBLISHED IN THE MARCH 2018 *JOURNAL OF SHIP RESEARCH*

A wave-balancing approach, where a ship is hydrostatically balanced on a wave with either the crest or the trough at midship, is often used to assess the inherent strength and stability of the vessel in waves. This work examines the differences between the wave types (sinusoidal and trochoidal) as well as the values of wave length, wave height, and position of the crest along the ship, with the goal of looking for the worst-case conditions for both intact stability and longitudinal strength. A notional destroyer is used as a case study to look at the trends in strength and stability in the upright condition and at angles of heel in waves. The notional destroyer is intentionally similar to but not the same as any existing design. The study shows that looking at a wider set of wave conditions and ship states can identify more extreme wave loading and stability degradation, suggesting that this more detailed analysis would be beneficial as a standard practice.

Residual Strength Analysis of a Damaged WWII T2 Tanker

BY COLIN BONNICI, CLAIRE DE MARCO MUSCAT-FENECH, AND ROBERT GHIRLANDO

Department of Mechanical Engineering, Faculty of Engineering, University of Malta, Msida, Malta

PUBLISHED IN THE MARCH 2018 JOURNAL OF SHIP RESEARCH

S.S. *Ohio*, the T2 tanker that replenished Malta during the Second World War in 1942 saved the Islands from capitulation. En route, the tanker was bombarded and heavily damaged but remained afloat. This historic event provided a research opportunity to analyze the tanker's residual strength and how she survived. A strength assessment of the damaged hull indicated that the S.S. *Ohio* was at risk of collapse. However, simple beam theory indicated that when least damaged, large bending moments were exerted on the ship's midship but diminished with further damage, providing evidence on how S.S. *Ohio* survived, shedding light on this 75-year-old mystery.

A Simplified Method for Analyzing Water Impact in the Initial Stages on an Elastic Rectangle Plate

BY HUA SUN[*†] AND DE-YU WANG[*†]

[*]*State Key Laboratory of Ocean Engineering, Shanghai Jiao Tong University, Shanghai, China*
[†]*Collaborative Innovation Center for Advanced Ship and Deep-Sea Exploration, Shanghai, China*

PUBLISHED IN THE MARCH 2018 JOURNAL OF SHIP RESEARCH

For most flat-bottom marine structures, impact loads are generated by complex transient coupling effects of solid, air, and water. However, simplified forecasting methods to obtain impact loads and dynamic responses of flat-bottom structures by considering both hydroelastic and air cushion effects are rare. In this article, a new simplified analytical method of water impact on the elastic plate is proposed based on Verhagen's model for the rigid plate. The analysis is focused on the initial stage during which the highest hydrodynamic loads are generated. Interactions between the plate, the air, and the water are simulated and analyzed. Also, fluid-structure coupling results by simplified method are compared with numerical results from Arbitrary Lagrangian–Eulerian method in LS-DYNA code. Experimental results are used to validate the feasibility and accuracy of the simplified method. Water impact on plates with different drop heights, rigidities, and added mass is analyzed. The air cushion effect, elastic effect, and three-dimensional effect in the simplified model are also discussed.

GO DEEPER

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Acronyms, names, and terms appearing in this issue

AR: augmented reality

ASSA: The Apprentice School Student Association at Newport News Shipbuilding, responsible for apprentice educational and social activities, community service, and representing the student body

EIR: Engineer-in-Residence, a program administered by Professional Engineers Ontario (PEO)

Executive Order #24: Issued on July 1, 1919 by Homer L. Ferguson, president and general manager of Newport News Shipbuilding and Dry Dock Company, authorizing pay for apprentices for classroom instruction during the workday

Experience Maritime: a four-day maritime awareness program at the Seattle Maritime Academy

HA/DR: humanitarian assistance/disaster response, missions undertaken by National Security Multi-Mission Vessels

HAUV: hovering autonomous underwater vehicle, developed by Franz Hover. The HAUV can inspect complex marine structures completely autonomously

ICME: integrated computational materials engineering

Isaac Webb: 19th century shipbuilder and father of William H. Webb

LIFT: Lightweight Innovations for Tomorrow, a Detroit-based manufacturing institute

MECA: Multicultural Education and Counseling though Arts, a Houston, TX-based organization that organizes the Sunburst Summer Camp

MRC: mixed reality continuum, in between virtual reality and augmented reality

NCEES: National Council of Examiners for Engineering and Surveying

NSMV: National Security Multi-Mission Vessels, training ships owned and funded by the United States Maritime Administration

PEO: Professional Engineers Ontario, responsible for regulating the practice of professional engineering in Ontario and for licensing professional engineers in the province

PPE: personal protective equipment

Primary Engineer: an educational program in the U.K., begun in 2005, that brings engineering and engineers into primary classrooms and curricula

RoboTuna: laboratory robot that was was instrumental in developing the principles of unsteady propulsion as employed by aquatic animals

Seafarer's Ability Assessment Standard of People's Republic of China: a set of guidelines issued by the Maritime Safety Administration of the People's Republic of China

SMA: State Maritime Academies

VR: virtual reality

WAM: Webb Alumni Mentorship program

WCSC: World Class Shipbuilding Curriculum, part of the Apprentice School at Newport News Shipbuilding. The curriculum includes 13 basic courses in mathematics, physics, mechanics, drafting, ship construction, business, computers, and communications

William Hovgaard: professor in charge of the course for naval constructors at MIT from 1901 until 1933

William H. Webb: shipbuilder, businessman, philanthropist, and founder of Webb Institute

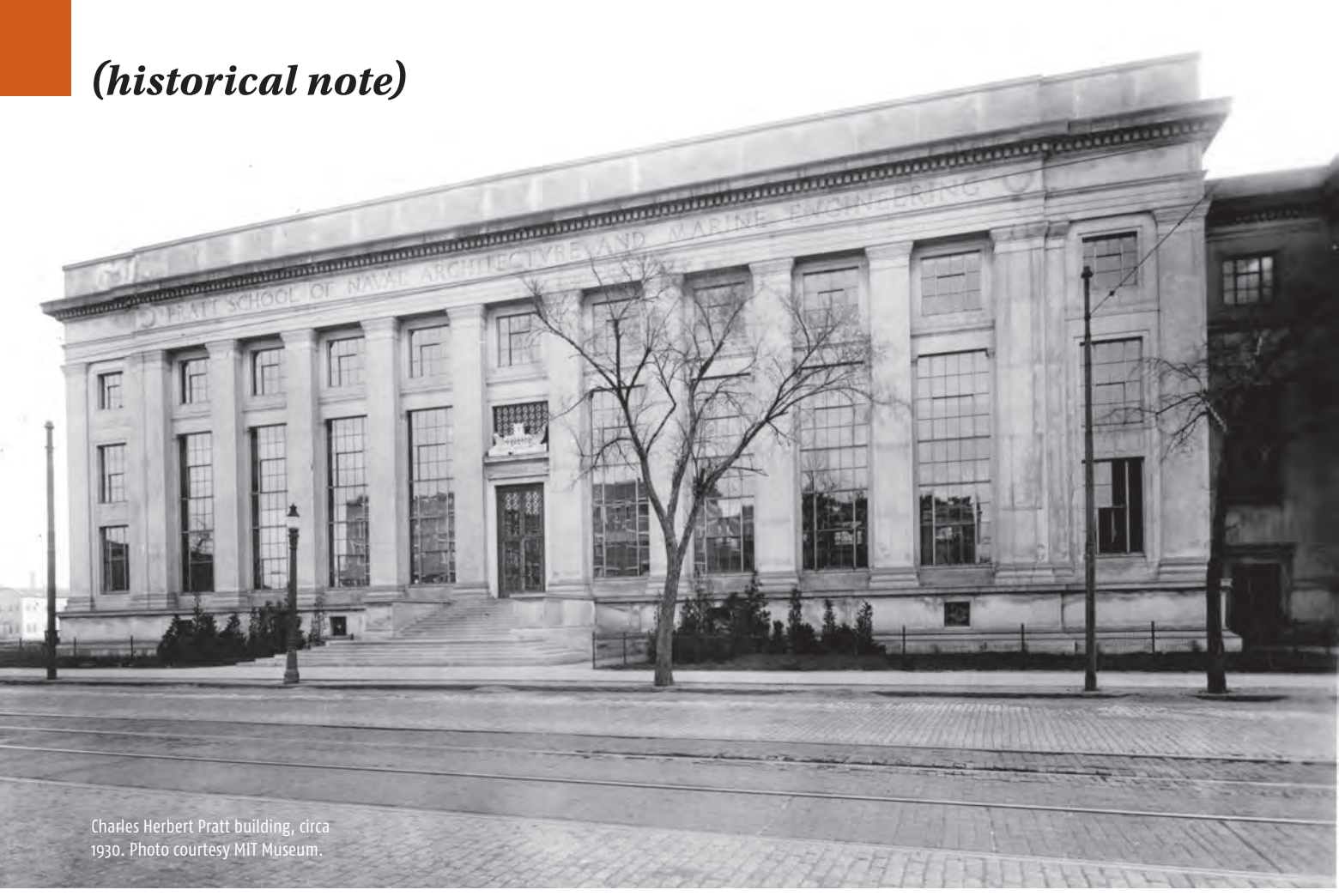
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SNAME has opened doors to the world of naval architecture and engineering and has provided tremendous opportunity for personal and professional growth. As a member of the society, I've been encouraged to continually learn, to love what I do, and to foster teamwork.

Mario Enrique Godoy Medina
Student Chair
University of Veracruz



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Charles Herbert Pratt building, circa 1930. Photo courtesy MIT Museum.

On the Banks of the Charles

MIT's course 2N has prepared naval officers for more than 120 years

BY CAPT JOE HARBOUR

Sitting on the northern bank of the Charles River, in the midst of one of the country's most culturally diverse areas, lies the Massachusetts Institute of Technology (MIT). Each year, MIT graduates a third of its roughly 600 mechanical engineering graduate students pursuing masters, engineers, and doctorate degrees. Students come from around the world to participate in lectures by world-leading research professors and scientists and to work alongside them in their laboratories creating the technologies that shape our future.

The graduate program in naval construction and engineering is intended for active duty officers in the United States Navy (USN), United States Coast Guard (USCG), and foreign navies who have been designated for specialization in the design, construction, and repair of naval ships and submarines. The curriculum, sponsored by Naval Sea Systems Command, prepares these officers for careers in design, acquisition, and maintenance of the most complicated vessels on the seas. Besides providing the officers a comprehensive education in naval engineering, we emphasize their future roles as advocates for innovation in ship design and acquisition. All officers write a thesis directed toward research that supports innovation in their service. The course of study consists of a two-year program, which leads to a master of science degree in naval architecture and marine engineering; or a three-year program, which leads to the degree of naval engineer.

The principal objective of both the two- and three-year programs is to provide a broad, graduate level technical education for a career as a professional naval engineer with ship orientation. In addition to concentrating on hydrodynamics, structures, and design, the curricula of both programs provide an appreciation for total ship engineering in a manner not covered in traditional mechanical, electrical, structural, or nuclear engineering. The curriculum emphasizes ship design through a sequence of five subjects starting with naval architecture and culminating in "Projects in New Construction Naval Ship Design," wherein the students couple knowledge gained from first principle,

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On the Banks of the Charles *continued*



William Hovgaard. Photo courtesy MIT Museum.

highly technical education with practical application of design to produce an original concept ship design.

The design project, along with the graduate thesis, represents the culmination of the three-year Naval Construction and Engineering program and students present their work at an annual ship design and technology symposium held in early May.

A long history

In August 1897, the chief naval constructor, Commodore Hichborn, requested MIT to develop and offer a three-year course of study for the professional training of naval constructors. MIT responded to this request and a course of study was agreed upon. The three years of work were designated as the junior, senior, and graduate years. Successful completion of the course led to the master of science degree. In 1901, three graduates of the United States Naval Academy, Ensigns Ferguson, McEntee, and Spilman, began the course of study under the direction of Professor William Hovgaard.

An 1877 graduate of the Danish Naval Academy in Copenhagen, Hovgaard served in the Danish Royal Navy until 1883 when he was sent to the Royal Naval College in Greenwich, England, to study warship construction. He graduated from its three-year course in 1886 and the next year published his first naval book, *Submarine Boats*. In 1901, as a commander in the Danish Navy, he came to the U.S. to continue his study of the submarine and was induced by the secretary of the navy, John D. Long, to take charge of the new course for naval constructors at MIT, with a focus on warship design. Hovgaard resigned from the Danish Navy as a captain in 1905. He was head of the new course, designated XIII-A, until 1933 when he retired as a professor emeritus. During his years as head of course XIII-A, Hovgaard taught hundreds of naval officers and authored several widely-used textbooks. Since 1921, the program offices have resided in the Pratt School of Naval Architecture and Marine Engineering, or building 5, which was erected under a grant by Charles Herbert Pratt.

The original attendees of the program, naval academy graduates, were officially attached to the Navy Yard in Charlestown and were registered as regular MIT students. The faculty maintained close relations with the chief constructor in Washington and with the constructors and top civilian staff at the Navy Yard and Fore River Ship and Engine Company in Quincy. This served two purposes: the instruction at MIT was being adapted to the needs of the service, and the faculty could use the work under construction at both yards to illustrate the classroom instruction. The course schedule was arranged to permit the students to spend one afternoon a week at the Navy Yard. The yard has since closed, but the program is closely linked to the Engineering Duty Officer Qualification program where officers are detailed to design, new construction and to repair yards upon graduation to receive on-hands training to augment the classroom lessons, and the Navy Yard site visits are incorporated to this day into the graduate program.

Warship design

The course for naval constructors differed from the regular course XIII studies in that it was more intensive, more advanced, and was focused on warship design versus ocean vessel architecture. A feature of the course, presented from the beginning, was that it fully immersed students in the various subjects not only with lectures, but also with projects and practical assignments. These were designed to provide hands-on experience in drawing, machine tool work, laboratories, and—through technical evolution—computer aided design tools.

Since 1910, instructors in the XIII-A curriculum have also been commissioned navy officers. The first, Professor Henry H. W. Keith, with course XIII-A from 1910-1945, was commissioned a lieutenant commander in the Corps of Naval Constructors during World War One. Instructor Harold Larner (1916-1917) also held a naval commission and retired as a captain. From 1910-1945, course XIII-A relied on long-term instructors such as Hovgaard (captain, Danish Navy, 1901-1933), Keith (captain, USN, 1910-1945), and Rossell (captain, USN, 1931-1946) to lead the naval construction program.

In 1945, the Navy's Bureau of Ships inaugurated the practice of detailing two active duty officers as professors for relatively short terms (two to three years). At any given time, one officer would be a trained and experienced naval architect and the other a naval engineer. Ever since, there have been two active-duty engineering duty officer faculty for the Naval Construction and Engineering program and officers from the U.S., Hellenic, Israeli, Thai, Turkish, and Canadian navies and USCG in the program. Officer students are admitted, and navy faculty members are appointed, through normal MIT procedures. The program is based on voluntary collaboration for the mutual benefit of MIT and the navy.

In January 2005, the Department of Ocean Engineering merged with the Department of Mechanical Engineering. The Naval Construction and Engineering Program, formerly called XIII-A, is now course 2N in the Center for Ocean Engineering, Department of Mechanical Engineering. **MT**

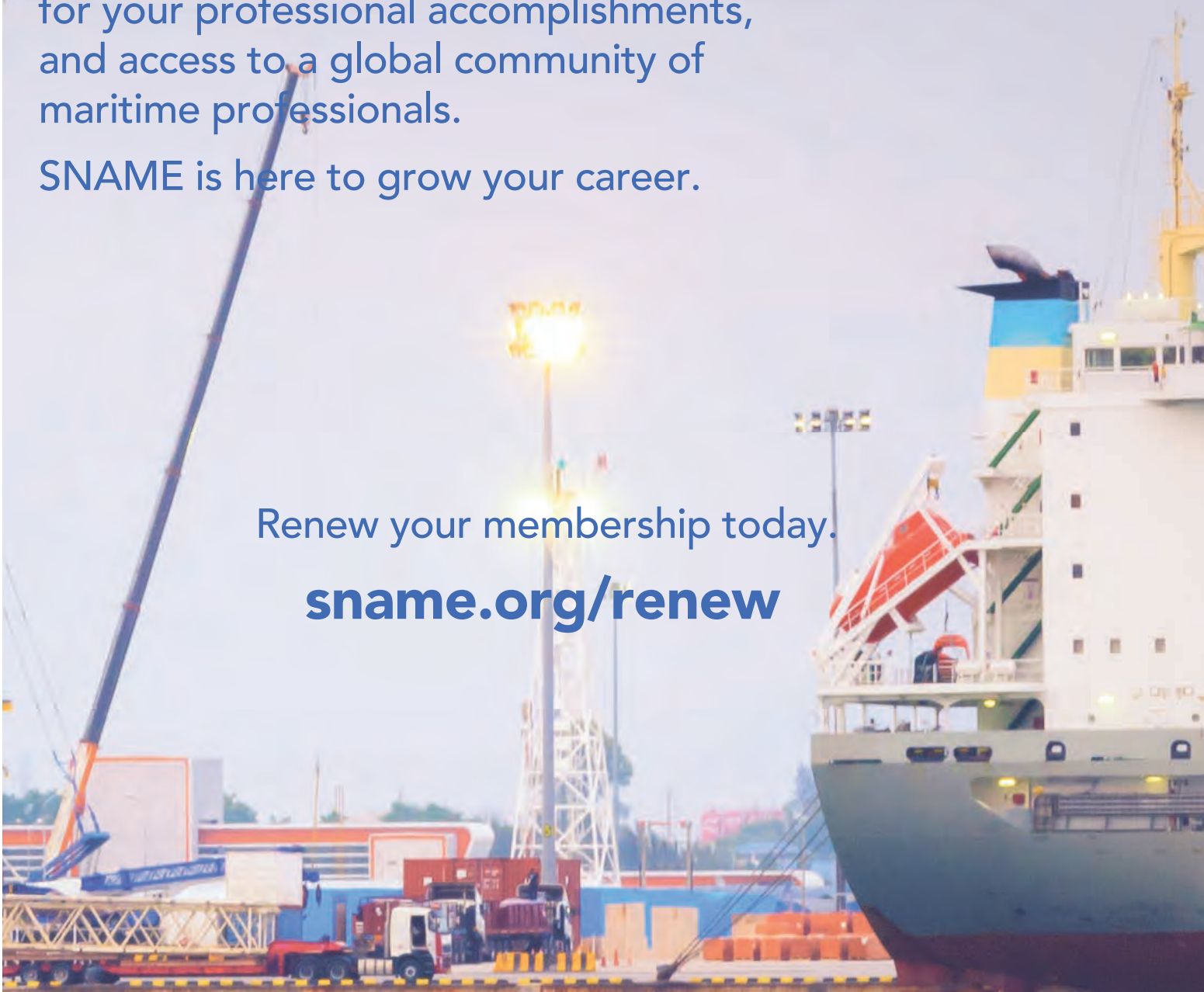
CAPT Joe Harbour *is director, naval construction and engineering at the Massachusetts Institute of technology.*

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