The Coast Guard Journal of Safety & Security at Sea

Proceedings

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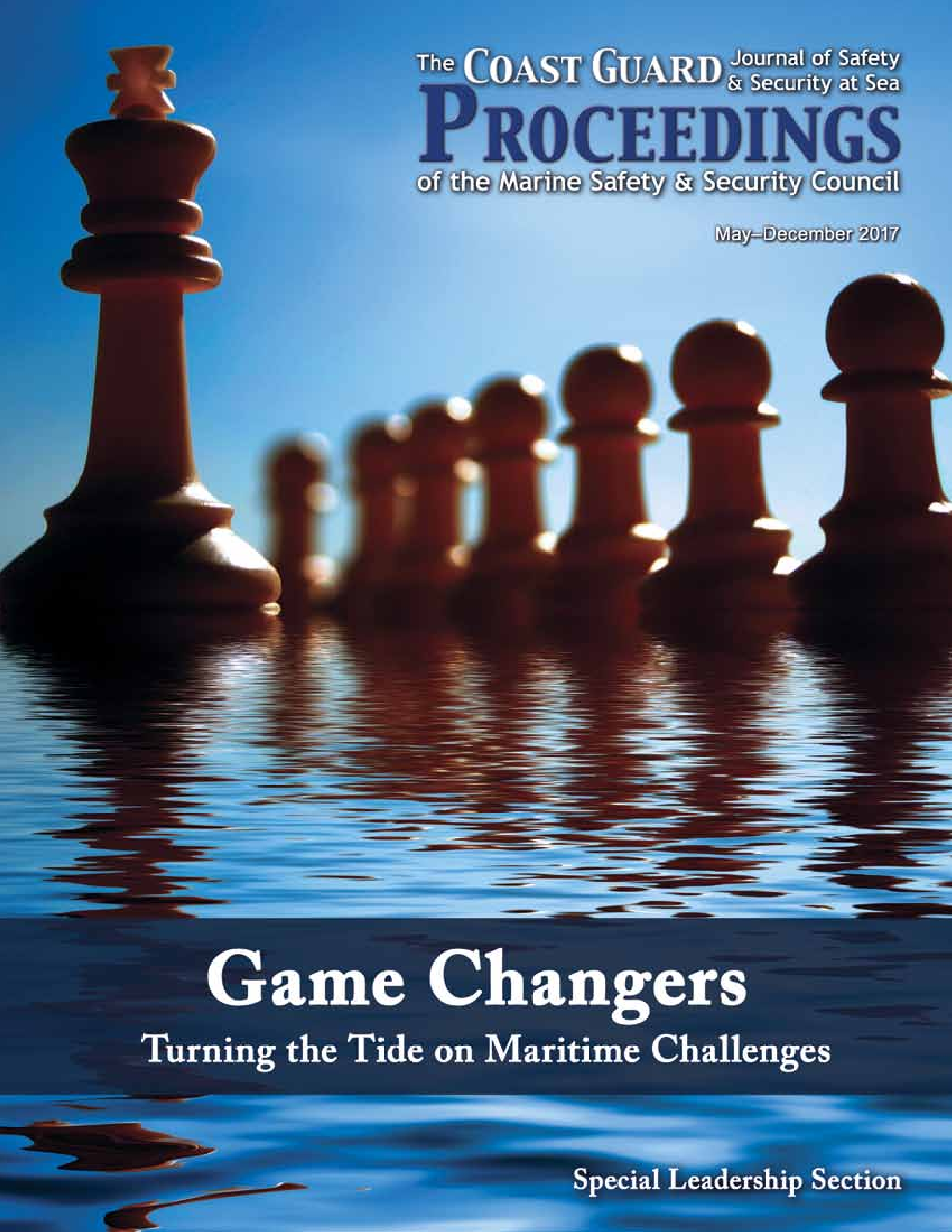
May–December 2017



Game Changers

Turning the Tide on Maritime Challenges

Special Leadership Section

PROCEEDINGS

May–December 2017

Vol. 74, Number 2

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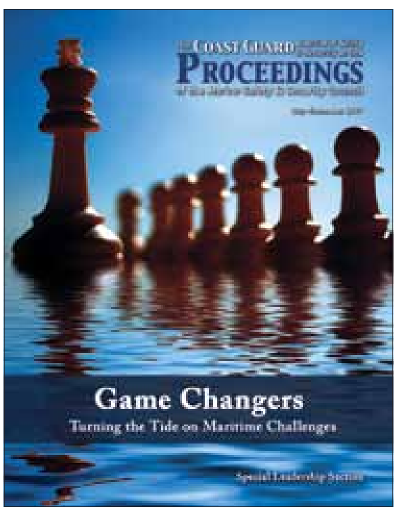

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Commandant's Perspective

by Admiral Paul F. Zukunft
Commandant, U.S. Coast Guard

The roots of the United States Coast Guard date back to 1790, when President George Washington signed the Tariff Act, authorizing up to 10 cutters to enforce customs laws and collect revenue.

Then-Secretary of the Treasury, Alexander Hamilton, urged the creation of the Revenue Cutter Service because he understood that "a few armed vessels, judiciously stationed at the entrances of our ports, might at a small expense be made useful sentinels of the laws." This 226-year-old quote from Federalist Paper No. 12 illustrates our founding father's vision. Hamilton knew of the maritime advantage: the power of harnessing this nation's most important geographic attribute—our waterways. The United States is truly blessed with a latticework of inland waterways that run east and west, north and south, connecting our nation's heartland with deep-water ports and global maritime commerce.

Indeed, Hamilton had a vision, but there is no way even he could have envisioned what was to become of our Maritime Transportation System (MTS) today. We enjoy one of the largest systems of ports and waterways in the world—25,000 miles of waterways that connect about 1,000 harbor channels, more than 300 ports, and 3,700 terminals. Our MTS accounts for more than $4.5 trillion of our nation's economic activity on an annual basis and supports 250,000 American jobs. It is the envy of the world.

In the Coast Guard's 226 years, we've faced countless "game changers" that impacted how we safeguard and secure our MTS. Ships went from wood to iron, and sail to steam, and signal flags to radios. Containerization was also an incredible game changer. Then, consider external events; like the tragedy of 9/11, which led to the International Ship and Port Facility Security Code (ISPS) and Maritime Transportation Security

Champion's Point of View

by Mr. Francis J. Sturm
Deputy Director, Commercial Regulations and Standards
U.S. Coast Guard

Many of the improvements in marine safety, security, and environmental protection throughout history were prompted by key events or maritime industry innovations. These "game-changing" events were, too often, major accidents that led government safety officials, as well as industry leaders, to take a closer look at the standards for the safe construction and operation of ships. Standards have also been developed and implemented to keep pace with game-changing technology introduced into the maritime arena.

Our vision for this edition of *Proceedings* is to provide you, the reader, with information about some of these key events and current industry trends causing standards to evolve, and some early indicators of potential future game changers.

One author writes about the sinking of the *Marine Electric* off the United States' east coast, Act (MTSA); or the *Exxon Valdez* oil spill, which prompted OPA-90 legislation.

Today, we find ourselves on the precipice of yet another game changer.

Technological advances have fueled unprecedented growth and efficiency in our globalized economy. We have witnessed incredible advances in our MTS, without which we would not see the $4.5 trillion in economic activity referenced earlier. When I visited Long Beach Container Terminal, I felt like I was watching a George Lucas production—though Star Wars was set a "long time ago," I was definitely witnessing the future. Everything is automated. Automated vehicles move the containers to the automated stacking cranes that sort and stack, and when the battery is low, the vehicle drives itself to the charging station.

Our entire MTS is inextricably linked to information technology—everything from navigation, communications, engineering, cargo tracking, vessel loading, ballasting, weather forecasting, vessel routing, safety, and environmental control, not to mention security monitoring, fire alarms, and flooding control. All of this relies on technology. When I think of how much has changed since I stepped foot on my first ship, Coast Guard Cutter *Taney,* some 40 years ago, it boggles my mind. And yes, if you were wondering, the same *Taney* that is now a museum.

These advances are not slowing down. In fact, they are speeding up. In 1984, there were 1,000 objects connected to the internet. In 1992, 1 million. In 2008, 10 billion. In 2020, this number is expected to grow to 50 billion. It's Moore's Law: the growth and complexity of technology is accelerating at astounding rates, and we humans struggle, no doubt, to keep pace.

For all this amazing progress, of course, there is risk. Exploitation, misuse, or simple failure of cyber systems can derail vital activities and cause massive financial losses. Most importantly, it can cost lives.

These risks are not theoretical. In 2012, more than 120 ships experienced malicious jamming of GPS signals and a number of major Asian coast guard vessels were impacted by the event. Mobile offshore drilling units have driven off-station due to disruption to their dynamic positioning systems. In Europe, organized crime has reportedly exploited a container terminal's system to facilitate drug smuggling.

The cyber domain poses some of the most difficult economic and national security challenges we face as a nation today. Indeed, challenges in the cyber domain are the next big "game changer."

The Coast Guard has a long history of working with the maritime industry, as well as federal, state, and local government stakeholders, to address risks associated with new threats and technologies. Today, guided by our strategy, we take on challenges in the cyber domain. Area maritime security committees evaluate cyber threats alongside more conventional risks as they evaluate security risks in their ports. And we work with the International Maritime Organization to provide cyber risk management guidance to vessel and facility operators to safeguard and secure our vital MTS, as well as the global industry.

Guided by the tenets of our Cyber Strategy, the Coast Guard has embraced this new "game changer." In cooperation with all of our maritime stakeholders, the United States Coast Guard will continue to adapt, as we have for more than 226 years, to meet the challenges of today and tomorrow, in the cyber domain and beyond. This is yet another "game changer" we will meet—head on.

Semper Paratus!

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which was a game changer for marine safety that led to new safety requirements for ships, changes in the way the Coast Guard conducts its marine safety responsibilities, and the creation of the USCG's rescue swimmer program.

Other authors lay out the background behind the creation of the Oil Pollution Act of 1990 and ensuing regulations. They also address the IMO ISPS Code and MTSA legislation for a huge suite of maritime security requirements, the STCW convention, and regulations improving medical standards associated with obtaining a Coast Guard merchant mariner credential.

You can read about how events like the *Deepwater Horizon* accident have impacted the offshore industry, leading to changes in safety standards for the MODU Code and vessels with dynamic positioning systems.

We have articles that focus on relatively new standards, or works in progress, to address impacts of shipping on the environment, including ballast water management to control the transmission of aquatic nuisance species and reducing air emissions through the use of batteries or alternative fuels to propel ships.

We also have articles about alternatives to conventional methods used in safety regulations, including the use of third-party organizations to inspect towing vessels on behalf of the Coast Guard, the use of industry standards instead of regulations for parasailing boat safety, and the evolution of the process the Coast Guard uses to develop regulations.

Several authors address cybersecurity challenges that have come to light over the last five years. Another author explains how the insurance market is dealing with many of these evolving maritime industry risks.

You can read about future game changers like the possibility of autonomous vessels, developments in robotic hull cleaning, and a speculative view on how vessel safety inspections may look in 2050.

Finally, a bonus section focuses on leadership challenges in the maritime community.

We hope these articles give you an appreciation for events that changed the way marine safety has been, and continues to be, improved in the U.S. and around the world.

Exxon Valdez and OPA 90

How congressional reaction to a major oil spill changed the U.S. Coast Guard

by CAPT Dennis L. Bryant
U.S. Coast Guard, Retired

The tanker *Exxon Valdez* departed the terminal at Valdez, Alaska, on March 24, 1989, carrying 55 million gallons of North Slope crude oil to the Long Beach, California, refinery. Several hours later, the tanker grounded on Bligh Reef in Prince William Sound, spilling about 11 million gallons of its cargo.

The master had retired to his cabin shortly before to get some rest. The third mate, also possibly exhausted, was not certified to pilot the tanker unsupervised in Prince William Sound. After leaving the channel to avoid ice, the tanker was not promptly navigated back to its proper course, and it grounded on the charted and marked rocks.

While the Alyeska Pipeline Service Company had basic spill response equipment stored at the Valdez terminal, the equipment had recently been removed from its barge for maintenance purposes. In addition, response personnel had not been provided proper training in the deployment and use of the equipment. Thus, when the grounding and spill occurred, there was no meaningful and immediate response.

The *Exxon Valdez* remains in place in Prince William Sound after running aground. The grounding resulted in the largest oil spill from a ship at the time. U.S. Coast Guard photo

Under the Federal Water Pollution Control Act (FWPCA), the U.S. Coast Guard was the lead federal agency with respect to maritime oil spills, yet had only limited authority to force polluters to take action in the event of a spill. While the Coast Guard had the authority to take over, or "federalize," the spill response, it had limited personnel and funding to undertake this course of action. Monies from the Oil Spill Liability Trust Fund could not be used to defray the expenses, as response to this particular spill came under the Trans-Alaska Pipeline Liability Fund, which proved wholly inadequate.

Cleanup continues as workers steam blast rocks and wash down shorelines soaked in crude oil from the leaking tanker *Exxon Valdez*. U.S. Coast Guard photo

For a variety of reasons—including public outrage to the oil spill and heavy pressure from the federal and state governments—the Exxon Oil Company agreed to waive its limit of liability, fully fund the response effort, and assume responsibility for personal and civil damages. Costs quickly rose into the millions. This became the largest oil spill in U.S. history to that date in terms of volume and environmental impact.

Congress quickly became aware of the shortcomings of the current system for reducing the risk of marine oil spills and minimizing their impacts. A number of House and Senate committees conducted hearings, and some old bills that had failed in previous sessions of Congress were dusted off and reintroduced. New bills were drafted and introduced to address particular issues as they were identified.

Working to prevent, improve response

The U.S. Coast Guard and the International Maritime Organization (IMO) had been discussing the concept of double hulls for several years, but there were unresolved concerns about the overall safety of such a measure. Congress had no such concerns, and a bill mandating double hulls on new oil tankers gained broad support.

The inadequacy of the initial spill response drew heavy criticism, prompting the introduction of bills to establish standards for spill response equipment and response personnel training. In addition, a bill was introduced to authorize the Coast Guard to mandate that polluters immediately respond to spills, and oversee that response.

Another bill was introduced to combine the three separate oil spill liability trust funds into one. Limits of liability were raised and the elements of liability were expanded, while exceptions to liability were reduced.

Eventually, all of these separate bills were combined into one and titled the Oil Pollution Act of 1990 (OPA 90). Congress unanimously voted to pass the measure on August 18, 1990.

President George H.W. Bush delegated most of his authority under OPA 90 to the secretary of transportation, Samuel K. Skinner, who further delegated authority to the USCG commandant, Admiral J. William Kime. This delegation to the Coast Guard was the largest single new regulatory tasking in its history. It involved more than 40 rulemaking projects and 10 major studies. Some of the projects had statutory deadlines that were impossible to meet as a practical matter. In addition, the taskings placed the Coast Guard under unprecedented public and political pressure.

In order to allow personnel charged with implementing the taskings to focus on their assignments, Admiral Kime established two special groups. The National Pollution Funds Center was charged with consolidating the disparate pollution trust funds and implementing the new consolidated Certificate of Financial Responsibility (COFR) program. The OPA 90 staff was charged with implementing all the other taskings. Composed largely of volunteers from throughout headquarters, the OPA 90 staff was authorized to borrow other federal and state employees and hire contractors to perform clerical and administrative duties. The staff brought together individuals with disparate skills. There were naval architects, marine inspectors, surface operations specialists, marine engineers, environmentalists, economists, and lawyers all contributing to the tasks at hand.

As regulatory proposals were developed, the maritime industry raised technical objections, arguing the proposals went too far. The marine insurance industry objected to the COFR proposal, threatening to withhold coverage for oil spills in U.S. waters and raising the possibility of a so-called "train wreck" by preventing tankers from delivering imported oil to U.S. refineries. Environmental advocacy groups complained the USCG proposals did not go far enough to protect the marine environment. Congressional committees demanded regular updates on the implementation effort, while individual senators and representatives objected to proposals that might adversely impact particular constituents or concerns.

Through it all, the dedicated members of the OPA 90 staff kept their heads down, working diligently on their projects. Realizing the maritime industry knew more about how ships were designed and operated than they did, and that environmentalists knew more about environmental issues, the staff undertook an unprecedented number of public meetings to gather as much input as possible. At these meetings, it was made clear that all input and comments would be carefully considered, but the Coast Guard would be the final judge of what was consistent with the letter and the spirit of OPA 90, as well as what was practicable.

There was one issue in particular vexing the staff, though. While standards for spill response equipment adequacy and personnel training were authorized by the statute, the law said nothing about how to get the job done. There were a number of companies able to engage in spill response, but the statute did not authorize the Coast Guard to regulate them.

It was impracticable for each ship owner and operator to inspect and evaluate the capabilities of these response companies. Eventually, a compromise was reached and the Coast Guard established the voluntary Oil Spill Response Organization (OSRO) program. Any company wishing to be classified by the Coast Guard as an OSRO had to demonstrate it possessed the required capabilities. In exchange, if a vessel owner or operator contracted with a classified OSRO to meet its spill response obligations, then that owner or operator did not have to otherwise inspect and evaluate that OSRO's capabilities—a win-win-win situation.

The Coast Guard was sued in federal court one time during this process. There was a relatively minor rulemaking project that had not been completed within the statutorily mandated time limit. An environmental advocacy group sued to have the federal court force the Coast Guard to complete the rulemaking. After hearing the arguments of both sides, the judge stated it to be a complex matter that he needed to take under advisement. When the project was completed some months later, the judge closed that case, ruling that the issues had become moot.

Except for a few loose ends, the implementation project was largely completed in the summer of 1995. Having successfully accomplished its primary mission, the OPA 90 staff was disbanded as a separate element and morphed into what is now the Office of Standards Evaluation and Development.

As important, OPA 90 has had significant, long-term impacts on the U.S. Coast Guard, which now reviews and approves—or sends back for amendment—spill response plans for all large vessels planning to operate in U.S. waters, as well as many waterfront facilities. It conducts or

OPA 90 Impacts and Implementation

The impacts of OPA 90 and its implementation continue to this day:

- **Oil tankers worldwide have double hulls**
- **The old single-hull tankers have been recycled or converted to other uses**
- **The U.S. spill response system is recognized as the best in the world**
- **The USCG COFR program provides the most protection of any such program in the world, largely ensuring that the polluter and/or its insurer pay the cleanup costs and damages arising from a spill**
- **The Oil Spill Liability Trust Fund has been structured so that damages incurred by any third party will be fairly compensated**

Chief Warrant Officer William Stacey rides back to shore after completing the initial boarding of the world's largest double-hull ultra large crude carrier, the 1,300-foot Greek-based tanker *Hellepont Alhambra*. U.S. Coast Guard photo by Petty Officer Dan Tremper.

Workers steam blast rocks covered in crude oil from the leaking tanker *Exxon Valdez.* U.S. Coast Guard photo.

supervises frequent oil spill response exercises around the nation, ensuring trained response personnel and adequate response equipment are always available. It also has ramped up vessel and facility inspections to more carefully examine personnel competence and equipment conditions. The civil penalty program has been expanded to include Class II civil penalties, with much higher monetary limits.

The National Strike Force, originally established in 1973, was enhanced to handle the increased responsibilities for USCG oil spill response. Additionally, the Incident Command System was adapted from California firefighting agencies to maritime oil spill response efforts to better coordinate and integrate efforts of federal, state, and local agencies, as well as non-government entities, under Coast Guard leadership.

Initially, the maritime industry strongly opposed OPA 90 and the implementation efforts. After all, those regulations resulted in about $6 billion in added costs for the industry. In hindsight, the industry generally supports the program and it now acknowledges ships are safer and less polluting than they were prior to OPA 90. In fact, the amount of oil entering the waters of the United States from ships has been reduced by more than 75 percent since 1989.[1] When a spill does occur, the response is prompt, efficient, and remedial action is certain.

The human and environmental consequences of marine oil spills have been greatly reduced as a result of OPA 90, and the marine environmental protection missions of the U.S. Coast Guard have been significantly broadened.

About the author:

Dennis L. Bryant, Captain, USCG (ret) is a 1968 U.S. Coast Guard Academy graduate. Among his assignments was supervising the special staff charged with the Coast Guard's implementation of the Oil Pollution Act of 1990 (OPA 90). He is now the principal at Bryant's Maritime Consulting, a maritime regulatory and environmental consultancy.

Endnote:

1. National Academy Press (NAP), Double-Hull Tanker Legislation: An Assessment of the Oil Pollution Act of 1990 (Washington, DC 1998).

SS *Marine Electric*

Impetus for the Coast Guard's premiere rescue swimmer program

by LCDR Sarah Rousseau
Program Analyst
Office of Performance Management and Assessment
U.S. Coast Guard

The U.S. Coast Guard is widely known and lauded for its response efforts, especially the brave women and men who enter treacherous seas to rescue those in peril. What the public typically does not see is the tireless behind-the-scenes work Coast Guard marine inspectors do to prevent marine casualties and the deaths, injuries, property losses and damage to the environment that might otherwise result.

The Coast Guard is responsible for U.S. maritime safety, security and environmental protection. Coast Guard marine inspectors can be found crawling around the dirty cargo holds of an oil barge in the searing heat of the Texas summer, running rescue drills with the world's largest cruise ships between port calls, or providing daily shipyard oversight of the months-long construction of a deep draft vessel.

The Coast Guard maritime prevention program is continually evolving to meet ever-changing needs and challenges. As new technologies and industry practices emerge, the program responds with appropriate regulatory and policy adaptations. Unfortunately, the historic impetus for change has often been the result of a horrific maritime tragedy.

The SS *Marine Electric:* Tragedy

On February 10, 1983, the SS *Marine Electric,* a 605-foot bulk cargo ship loaded with coal, departed Norfolk, Virginia, en route to Brayton Point, Massachusetts, with 34 crew members onboard. Meanwhile, a winter storm was brewing off the coast of Virginia with winds from 35–55 knots and 4-foot seas. The next day, the *Theodora,* a disabled fishing vessel just outside of the Chesapeake Bay, was taking on water and requested assistance from the Coast Guard. Since the SS *Marine Electric* was in the vicinity, the Coast Guard requested they assist the *Theodora,* staying with the fishing vessel until she was able to continue on back to port. The SS *Marine Electric* obliged, and shortly after the *Theodora* made way toward port under her own power. The SS *Marine Electric* then continued on her course, pushing north through winter storm conditions that had intensified.

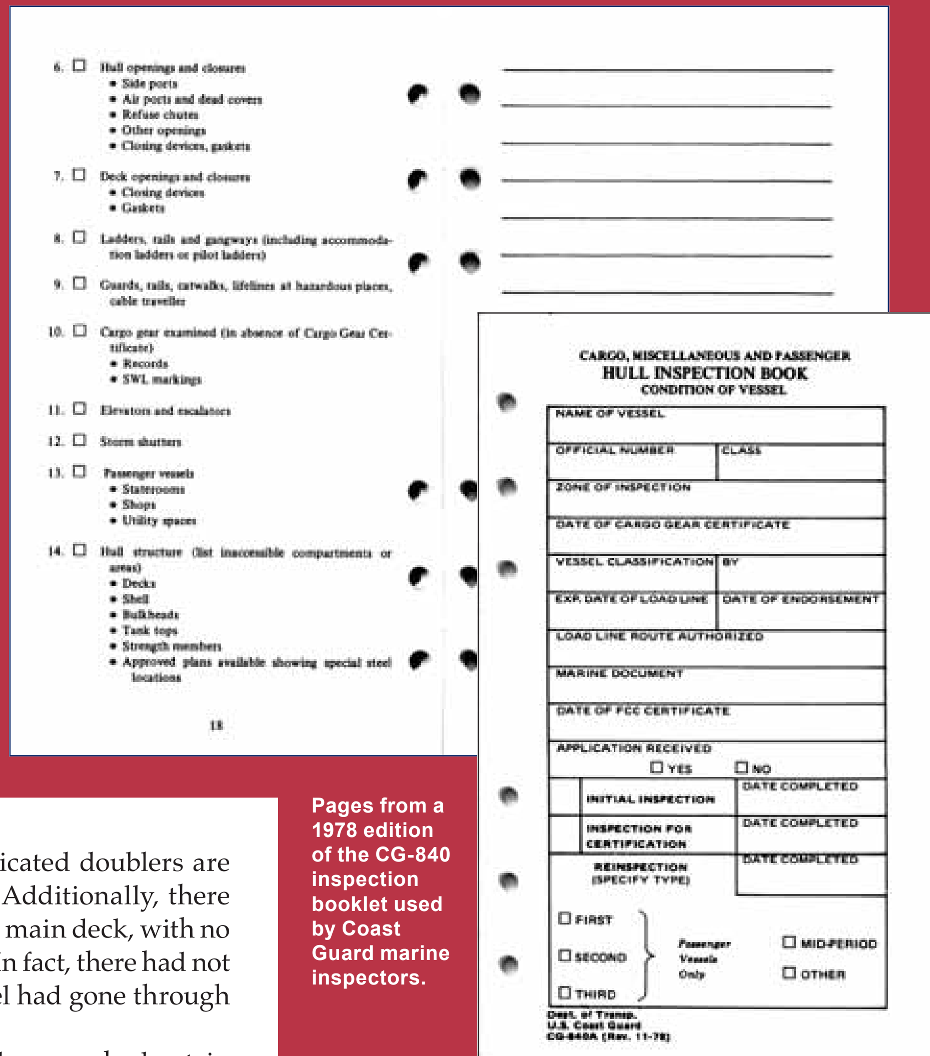
Late February 11, the winds picked up and the seas were over 40 feet. Crew members noticed the SS *Marine Electric* had been sluggish since earlier that evening. The captain ordered the crew to inspect the cargo holds where they discovered the ship was taking on water. The waves continued to batter the ship and finally, in the early hours of February 12, the SS *Marine Electric* succumbed to water ingress about the bow of the ship. Around 4 a.m., the captain sent out a distress call and ordered the crew to abandon ship. The waters off the coast of Virginia were a chilling 37 degrees Fahrenheit that morning. While the crew members were on the starboard boat deck trying to board the lifeboat, the vessel suddenly rolled and threw them all into the water, capsizing shortly thereafter. None of the crew members were wearing anti-exposure suits, as the vessel was not required to carry them along that route.

Upon receiving the distress call from the SS *Marine Electric,* Coast Guard Air Station Elizabeth City, North Carolina, immediately dispatched a helicopter to the scene. By the time the aircraft arrived, the 34 crew members had been struggling in the frigid waters for 90 minutes. Hypothermia had already set in and rendered them unable to climb aboard the Stokes litter, or rescue basket, that was lowered from the helicopter. Desperate, the Coast Guard called on the Navy to assist, knowing they had rescue swimmers and could potentially pull the SS *Marine Electric* crew members out of the water. Arriving on scene over two hours after the crew had abandoned ship, and conducting rescue operations for nearly an hour, the Navy rescue swimmers were able to save three of the crew members. The remaining 31 crew members passed away that night, victims to the icy waters in those fateful early morning hours. Seven were never recovered.

Results of the Investigation

The Coast Guard conducted a formal Marine Board of Investigation, which concluded that the casualty was the result of progressive flooding, exacerbated by wasted cargo hatches that easily gave in to the dynamic forces of mounting seas. The water ingress in the two forward cargo holds eventually caused the loss of stability until finally the vessel capsized and sank. The final report revealed the ship did not meet applicable load line regulations, nor the rules set forth by the American Bureau of Shipping (ABS). In fact, records indicated the ship had been deficient on several accounts despite having gone through an overhaul and several repairs, surveys, and inspections in the two years preceding the incident. It was riddled with more than 400 doublers, or metal patches, on the cargo hatches, even though established guidance indicated doublers are intended to be temporary and sparse. Additionally, there were more than a dozen doublers on the main deck, with no weather-tight seals on the hatch covers. In fact, there had not been weather-tight seals since the vessel had gone through a 1981 overhaul.

Going against regulation, the vessel owners had not, in some cases, notified the Coast Guard of repairs. Nor had the Coast Guard been proactive with the owners in working to ensure the vessel was properly maintained. In fact, some of the Coast Guard inspection paperwork even indicated inspectors had tested repairs, when in fact no such tests had been performed.


6. ☐ Hull openings and closures
- Side ports
- Air ports and dead covers
- Refuse chutes
- Other openings
- Closing devices, gaskets

7. ☐ Deck openings and closures
- Closing devices
- Gaskets

8. ☐ Ladders, rails and gangways (including accommodation ladders or pilot ladders)

9. ☐ Guards, rails, catwalks, lifelines at hazardous places, cable traveller

10. ☐ Cargo gear examined (in absence of Cargo Gear Certificate)
- Records
- SWL markings

11. ☐ Elevators and escalators

12. ☐ Storm shutters

13. ☐ Passenger vessels
- Staterooms
- Shops
- Utility spaces

14. ☐ Hull structure (list inaccessible compartments or areas)
- Decks
- Shell
- Bulkheads
- Tank tops
- Strength members
- Approved plans available showing special steel locations

18

CARGO, MISCELLANEOUS AND PASSENGER
HULL INSPECTION BOOK
CONDITION OF VESSEL

NAME OF VESSEL	
OFFICIAL NUMBER	CLASS
ZONE OF INSPECTION	
DATE OF CARGO GEAR CERTIFICATE	
VESSEL CLASSIFICATION	BY
EXP. DATE OF LOAD LINE	DATE OF ENDORSEMENT
LOAD LINE ROUTE AUTHORIZED	
MARINE DOCUMENT	
DATE OF FCC CERTIFICATE	
APPLICATION RECEIVED ☐ YES ☐ NO	
INITIAL INSPECTION	DATE COMPLETED
INSPECTION FOR CERTIFICATION	DATE COMPLETED
REINSPECTION (SPECIFY TYPE)	DATE COMPLETED
☐ FIRST ☐ SECOND ☐ THIRD } Passenger Vessels Only	☐ MID-PERIOD ☐ OTHER

Dept. of Transp.
U.S. Coast Guard
CG-840A (Rev. 11-78)

Pages from a 1978 edition of the CG-840 inspection booklet used by Coast Guard marine inspectors.

Marine Safety in the 1980s

In the early 1980s, the Coast Guard was converting their Marine Inspection Offices to Marine Safety Offices. The old organization emphasized the employment of unique and focused marine inspectors who were experts in their field. The new Marine Safety Offices added an emphasis on environmental response and focused on cross-training Marine Safety personnel in both inspections and response activities. This addition of new responsibilities, together with a shrinking federal budget, put the Coast Guard in "survival mode" with little hope of growing the workforce to meet its expanding duties. As inspectors took on additional responsibilities, the Coast Guard began relying more on third parties to shoulder the load.

During this period, as now, The American Bureau of Shipping (ABS) was the class society for most U.S.-registered vessels and was already routinely conducting ship surveys, which duplicated some of the inspection work carried out by Coast Guard marine inspectors. The Coast Guard seized the opportunity to capitalize on these additional, third-party resources. ABS was allowed to issue load line certificates and conduct other work that was intended to ensure a vessel was properly built to safely carry its intended cargo on behalf of the Coast Guard. This included routine inspections of a vessel's structure, including hull, deck plating, and cargo hatches. While they had the authority to issue and endorse load line certificates, ABS did not have the authority to revoke them for failure to comply. As Coast Guard inspectors conducted fewer and fewer load line inspections, they began to lose their expertise. Inspectors were becoming ill-equipped to properly and thoroughly inspect a ship under the Load Line Convention.

This forward panel on the No. 3 cargo hatch cover was removed from the SS *Marine Electric* in November 1982. This photo was taken in February 1983. U.S. Coast Guard photo.

In the case of the SS *Marine Electric,* the Marine Board of Investigation found the ship had undergone a drydock and overhaul in June 1981. During the drydock inspection, Coast Guard inspectors should have detected the deteriorated hatch covers, as well as large metal plates covering the cargo bilge wells and a deteriorated lifeboat. They should have also found that the vessel was in violation of its load line certificate, as well as its Certificate of Inspection. The board concluded these deficiencies indicated a lack of thorough inspection, but more importantly, a lack of competency and training.

In the aftermath of the SS *Marine Electric* in the mid-1980s, the Marine Board of Investigation determined that the Coast Guard should not delegate its Load Line authorities to third parties. The commandant non-concurred with the recommendation and made no moves to limit the use of third parties at the time. In fact, about a decade later, the Coast Guard began delegating more authority to third parties through the creation of the Alternate Compliance Program (ACP). Under the ACP, companies were given the option of having their compliance inspections conducted by an Authorized Class Society (ACS). The ACP was instituted in order to reduce the regulatory burden on vessel owners by eliminating duplicative aspects of Coast Guard inspections and ACS surveys.

Coast Guard inspections themselves were also undergoing changes. Today, inspections are well-documented in the CG-840 inspection books and inspection deficiency requirements forms. The inspection books now align vessel systems with the federal regulation or U.S. code mandating the requirements for those systems. In the early 1980s, however, these forms had no standard. They offered blank spaces for random notes.

The Coast Guard had already begun revising the marine safety training program before the SS *Marine Electric* sinking, including breaking down inspections into job tasks and tailoring marine safety curricula and qualification systems to meet the demands of those job task requirements.

Following this accident, the Coast Guard drafted new guidance on inspecting hatch covers and documenting excessive use of doublers. They also pursued regulatory changes to require better lifeboat accessibility and flooding alarms in inaccessible spaces during heavy weather.

Furthermore, in 1981, there was no guidance or policy on when an officer in charge of marine inspection could extend a vessel's drydock requirement. The SS *Marine Electric* had been granted a drydock extension from February 1983 to April 1983, but it was not accompanied by any sort of justification. It is worth noting that the SS *Marine Electric* was a T-2 cargo ship built during World War II for the purpose of shipping wartime needs overseas. These ships were initially designed for limited service and some of the vessels proved unseaworthy even before their maiden voyages. Yet some ships in this class were still operating in commercial service 40 years later. They were known for frequent stress fractures and even buckling under pressure. After the SS *Marine Electric* sank, the Coast Guard embarked on a critical review of these World War II ships leading to 70 being decommissioned due to their critically deteriorated conditions.

Coast Guard Search and Rescue

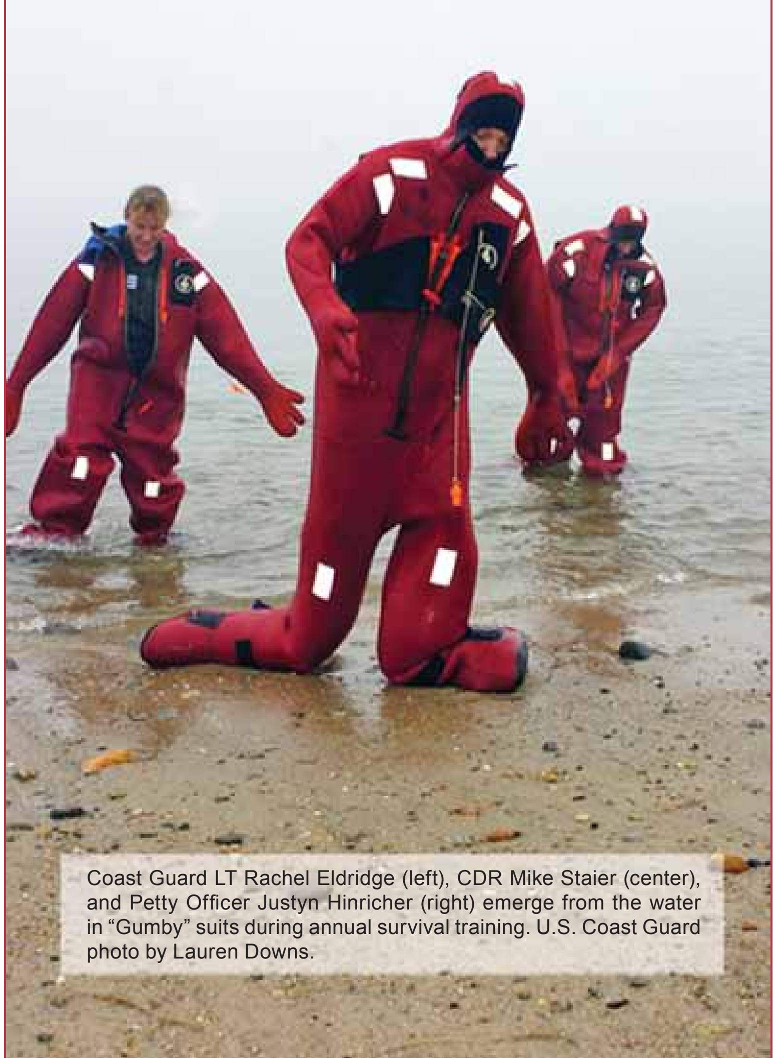
In 1983, the Coast Guard did not yet have its now world-renowned Rescue Swimmer program. At the time, rescue efforts involved lowering a Stokes litter from the helicopter for the victims to climb into. In the early 1980s, the Coast Guard still operated amphibious helicopters. In especially urgent circumstances, the flight mechanic, or more often the co-pilot, could be tethered to the helicopter and briefly enter the water to rescue a person in distress. The Coast Guard held the stance that a Rescue Swimmer program was too dangerous and would unduly risk the lives of the swimmers.

Congressman Gerry Studds from Massachusetts took on this challenge with vigor. The majority of the crew members aboard the SS *Marine Electric* were from his district. He was concerned the agency responsible for maritime search and rescue did not have the capability to save their lives. Serving on the House Committee on Merchant Marine and Fisheries, Congressman Studds promptly set up congressional hearings. The result was the Coast Guard Authorization Act of 1984, announcing, "The Commandant of the Coast Guard shall … establish a helicopter rescue swimmer program for the purpose of training selected Coast Guard personnel in rescue swimming skills."

The Coast Guard promptly combined efforts with the Navy to set up a training program and discuss procedures tailored to the mission needs for civilian

Anti-Exposure Suits

In the early 1980s, the Coast Guard was considering requiring anti-exposure suits onboard vessels. An anti-exposure suit is a protective suit designed to keep a person who is forced to enter cold water alive and prevent hypothermia. At the time of the SS *Marine Electric* incident, there was already a notice of proposed rulemaking requiring vessels to carry anti-exposure suits if those vessels operated in cold climates. However, the designated "cold climates" did not include the area off the coast of Norfolk, which is where the SS *Marine Electric* sank. The Marine Board of Investigation found anti-exposure suits might have extended the crew members' survival time by two to three hours. Today, U.S. regulations require anti-exposure suits when vessels are operating north or south of the 32nd parallels. In North America, that is approximately the border between Georgia and South Carolina, down the coast from the mouth of the Chesapeake Bay.



Coast Guard LT Rachel Eldridge (left), CDR Mike Staier (center), and Petty Officer Justyn Hinricher (right) emerge from the water in "Gumby" suits during annual survival training. U.S. Coast Guard photo by Lauren Downs.

rescue. Air Station Elizabeth City, North Carolina, the same air station that responded to the SS *Marine Electric,* became the first with rescue swimmers in 1985.

More than 30 Years Later

The Coast Guard Office of Investigations and Casualty Analysis works diligently to review tragedies like the SS *Marine Electric,* determine causal factors, and analyze trends in the maritime industry. Ultimately, they make recommendations to improve the safety of our nation's mariners and the marine transportation system that supports our robust economy.

The Rescue Swimmer program alone has accounted for tens of thousands of lives saved since its inception and is arguably one of the Coast Guard's most recognizable programs. And certainly the regulations resulting from the investigation have prevented countless other marine casualties. Fortunately, marine casualties like the SS *Marine Electric* have become far less frequent, affirming the value of the Coast Guard's Prevention Concept of Operations (CONOP). The CONOP includes the development of domestic and international standards for vessels, facilities, and mariners, a robust compliance regime, and investigations to determine causal factors of those casualties that do occur in order to make continuous improvements to the prevention continuum. Industry relationships serve to strengthen the CONOP even more, recognizing that as long as there are marine casualties there will be valuable lessons to be learned.

About the author:
LCDR Sarah Rousseau has served in the U.S. Coast Guard for 12 years. She currently works for the Office of Performance Management and Assessment as the analyst for the Maritime Prevention program, but her specialty and her passion are commercial vessel inspections and investigations.

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A rescue swimmer with Coast Guard Air Station Elizabeth City, North Carolina, jumps from a helicopter during training. U.S. Coast Guard photo by Petty Officer Joshua Canup.

Standards of Training, Certification, and Watchkeeping

Why, what, and how?

by Mr. E.J. Terminella
Office of Merchant Mariner Credentialing
U.S. Coast Guard

It's hard to believe the International Maritime Organization's (IMO) International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (or STCW), has been in force for more than 30 years. From the initial development of this international instrument, through its various amendments and consolidated reviews, the standards have become more refined and address numerous crew certificates and ship types. In this article we will touch on why this convention is so important to the global economy and what makes up the convention, its history, and structure. We will finish with details on how the standards contained in the convention are continuously updated, and efforts taken by the U.S. to remain fully engaged in the enhancement of the standards.

STCW—Why?

The need for a globally accepted training standard is undisputed. Marine casualties involving incompetence and negligence occurred for many years before and after the development of the STCW. You don't have to look back too far to find examples, including the *Torrey Canyon*, *Argo Merchant*, *Herald of Free Enterprise*, and the *Exxon Valdez*. The serious casualties involving these ships, as well as many other casualties each year, all had aspects of training and human factors that played a role in their occurrences. A review of U.S. Coast Guard marine casualty data shows that during the five years between 2010 and 2014, 75 percent of major marine casualties were caused by human factors, resulting in more than $900 million in property damage. These statistics show marine casualties, with the greatest impact to our fragile marine environment, have a tie to the standards contained within the STCW.

It is impossible to develop a standard that will eliminate all marine casualties or address intentional actions or choices which are inconsistent with normal decision-making. However, through the development of clear guidance on the competencies mariners should attain, the STCW undoubtedly provides the necessary clarity to those employed in the maritime industry regarding the levels of training, experience, and proficiency necessary to qualify for a certificate of competency.

STCW—What?

The STCW has grown substantially from its humble beginnings. The initial STCW 78 included only six short chapters containing the mandatory regulations with several non-mandatory resolutions providing additional guidance in various areas. Although a good start, the ambiguous language in the regulations led to inconsistent application across the signatory administrations. This ambiguity, coupled with the need to include provisions for watchkeeping and other operational areas spurred the IMO to embark on a major revision to the convention in the early 1990s. Over the course of several years, a consolidated review of the convention was undertaken, resulting in a number of substantive improvements to this instrument. These improvements included the addition of chapters for Alternative Certification and Watchkeeping, the development of a communication mechanism between signatories and

"… during the five years between 2010 and 2014, 75 percent of major marine casualties were caused by human factors, resulting in more than $900 million in property damage."

A Coast Guard helicopter prepares to hoist people off the tanker SS *Argo Merchant,* which ran aground off the coast of Nantucket, Massachusetts, in December 1976. Photo courtesy of the U.S. Coast Guard Historian's office.

the IMO Secretariat to demonstrate proper implementation, and the restructuring of the international instrument into two parts, the STCW Convention and the STCW Code. This work culminated in the 1995 amendments to the STCW, which entered into force on February 1, 1997.

The STCW Convention now contains the articles and regulations outlining the general convention procedures, the implementation requirements, and the associated applicability for the various competencies. The STCW Code contains the more technical requirements for implementation of the different certifications and training. In this way, it reduced the burden on IMO member states to make technical changes within the STCW Code and incorporate new areas of operational knowledge, as the procedures for making such changes are less arduous than the procedural requirements for amending the articles and regulations in the STCW Convention.

Following the work to develop the 1995 amendments, there were several amendments to include additional training requirements for personnel employed on bulk carriers and passenger ships, as well as training requirements for workers involved in aspects of ship security throughout the maritime industry. Noting there were additional areas of training for new technologies and emerging segments of the maritime industry that remained unaddressed, as well as a need for a review of existing requirements, there was a call from IMO member states to initiate a consolidated review. This work began in 2007 and, after a frenzied three years, resulted in the 2010 Manila Amendments. Similar to the work to develop the 1995 amendments, the outcome included a substantial revision to the international instrument. A few of the key improvements include the incorporation of the able seafarer certifications, the creation of certifications for electro-technical officer, development of non-mandatory training for personnel employed on ships in the polar regions, and increased specificity on rest requirements. The 2010 Manila Amendments entered into force on January 1, 2012, with a five-year transitional period to ensure all mariners became compliant with the new requirements no later than January 1, 2017.

Even though the last consolidated review resulted in substantive changes, amendment of the STCW has not ceased. Amendments to training of personnel on passenger ships, gas-fueled ships, and those employed on ships in polar regions have all occurred since 2010. The United States led some of these efforts, including the passenger ship training requirements. In the next section we will cover how the U.S. Coast Guard works with our domestic maritime industry and international partners to implement improved training requirements in the STCW, while ensuring those requirements are not overly burdensome.

STCW Chapters and Codes

STCW Convention chapters

- Chapter I: General provisions
- Chapter II: Master and deck department
- Chapter III: Engine department
- Chapter IV: Radio communication and radio personnel
- Chapter V: Special training requirements for personnel on certain types of ships
- Chapter VI: Emergency, occupational safety, medical care, and survival functions
- Chapter VII: Alternative certification
- Chapter VIII: Watchkeeping

The STCW Code

The STCW Code is broken into two areas. Part A contains the "Mandatory standards regarding provisions of the annex to the 1978 STCW Convention, as amended." Part B consists of "Recommended guidance regarding provisions of the 1978 STCW Convention, as amended." (STCW, 2010)

STCW—How?

As with any good set of standards, the STCW is under continuous review and revision to ensure its text is clear, concise, and includes the necessary information to address changes in the maritime industry. As can be expected, this review and the development of amendments is not an inconsequential process and includes input from domestic and international sources. As mentioned above, consolidated reviews of the STCW have taken place in the past. These types of actions take considerable effort over the course of many years due to their substantive nature. However, many other amendments to the STCW may be initiated outside of those consolidated reviews. This often occurs in cases where we see technological changes to ship operations or when information becomes available that highlights an operational area requiring additional training. When this happens, the U.S. Coast Guard employs a robust system to receive input from our domestic maritime industry in order to ensure that any changes to the STCW align, as far as practicable, with current or envisioned industry practice. We do this in two ways.

First, we engage the representatives of our federal advisory committees, including their Merchant Marine

International standards for mariner training and certification, like STCW, are developed by the International Maritime Organization's (IMO) Sub-Committee on Human Element, Training and Watchkeeping, shown here meeting at IMO Headquarters in London in February 2017. Photo courtesy of IMO.

Personnel Advisory Committee (MERPAC), which works closely with us to provide input on changes to the STCW. Members of MERPAC, and the industry representatives and private citizens who attend the meetings, represent a wide range of experience and perspectives allowing for the formulation of unified positions on topics under review. These unified MERPAC positions are then reviewed by governmental subject matter experts for inclusion into proposed U.S. positions.

This leads to the second method of obtaining private sector input. Prior to attending each IMO meeting, the U.S. Coast Guard holds open forums to obtain guidance and input from the broader maritime industry, including industry trade organizations and private citizens. Upon the completion of that process, U.S. representatives to the IMO have well-developed positions that reflect all viewpoints of the particular issues.

Furthermore, the United States ensures members of the various industry segments impacted by the agenda topics comprise our delegations to the IMO. These industry representatives provide our delegation with industry expertise to alter positions and compromise during the sometimes fluid discussions that occur during the meetings.

An excellent example of how this process has worked well, as it relates to the STCW, is the recent set of amendments made to the training requirements for those employed on ships using gas as fuel. Noting the increases in domestic production of liquefied natural and petroleum gas, and the increased ship traffic for this segment of the industry, the need to review existing training standards was emphasized. Working closely with MERPAC and outside industry experts, the United States delegation was able to bring proposals for what to include within an appropriate training standard to the IMO. As a result of this preparatory work, the IMO was able to produce the amendments to the STCW in a very short time period.

Training requirements associated with passenger ships is another recent example of how our partnerships with industry have proven vital in developing amendments to the STCW. Since more than 11 million passengers take cruises originating from a U.S. port each year,[1] and after reviewing recent marine casualty investigation findings involving passenger ships, the U.S. felt changes to the existing training standards were necessary. Noting this segment of the industry was represented by a trade organization, the U.S. believed a partnership between that organization and leading flag administrations was in the best interest to develop a standard that met our desires, while ensuring it was practical and able to be implemented. Through this close cooperation, a proposal was developed which served as the basis for the eventually agreed-upon amendments.

These types of partnerships are not unique to the U.S. Many IMO member states follow similar steps to develop consensus on amendments to the STCW prior to submission to the IMO. And it is only through these actions that the STCW can remain a vital, dynamic standard providing the necessary clarity on mariner training requirements.

STCW—Future?

In recent years we have seen amendments to the training for those personnel employed on passenger ships, gas fueled ships, and ships operating in polar regions. It's impossible to know where the next operational or technological advance will take place and how that will impact those employed on merchant ships. But one thing is certain: Through the hard work of many over the past four decades, the STCW Convention and Code contains the necessary standards for personnel to continue to operate ships safely and securely for many years to come.

About the author:

Mr. E.J. Terminella has been a U.S. Coast Guard civilian employee for 17 years, where he has filled positions within the Port State Control and Merchant Mariner Credentialing Programs.

Endnote:

1. 2016 State of the Cruise Industry Outlook

Security Since 9/11

Creating the Maritime Transportation Security Act and the ISPS Code

by LT Bill Gasperetti
Assistant Branch Chief, TWIC Implementation Branch
Office of Port and Facility Compliance
U.S. Coast Guard

History

While September 11 was the seminal event drawing the world's attention to the security implications of international commerce, there were always global transportation risks that concerned countries and companies. Some events are naturally occurring, such as storms, risks of contamination or spoilage, water and heat damage to cargo. Others, like smuggling, pilferage, and terrorism are manmade. Following the horrific 2001 terrorist attacks on American soil, the U. S. Congress decided something was needed to address the manmade side of the equation. On November 25, 2002, Congress passed the Maritime Transportation Security Act (MTSA) of 2002, directing the U.S. Department of Transportation (DOT) to develop security measures for domestic maritime facilities and the vessels that call there.

Moreover, DOT was tasked to learn about the anti-terrorism measures in place in foreign ports and to offer training to countries where security standards appeared to be inadequate. These missions transitioned to the Department of Homeland Security when the U.S. Coast Guard was moved to the new department in 2003.

The regulations required by the MTSA were enacted in July 2004. The MTSA is a significant piece of legislation which reinforces the national and global importance of security for the marine transportation system and provides a crucial framework for ensuring the security of maritime commerce and U.S. domestic ports. The goal of the MTSA is to prevent a Transportation Security Incident (TSI)—defined as any incident that results in:

- Significant loss of life
- Environmental damage
- Transportation system disruption
- Economic disruption to a particular area

International Ship and Port Facility Security Code

At the same time the U.S. was working to develop a maritime security regime domestically, the International Maritime Organization (IMO) was looking at the problem from a global perspective. The MTSA of 2002 and the International

Washington State Ferry: Washington State Ferry operations against the Seattle Skyline. U.S. Coast Guard photo by Petty Officer LaNola Stone.

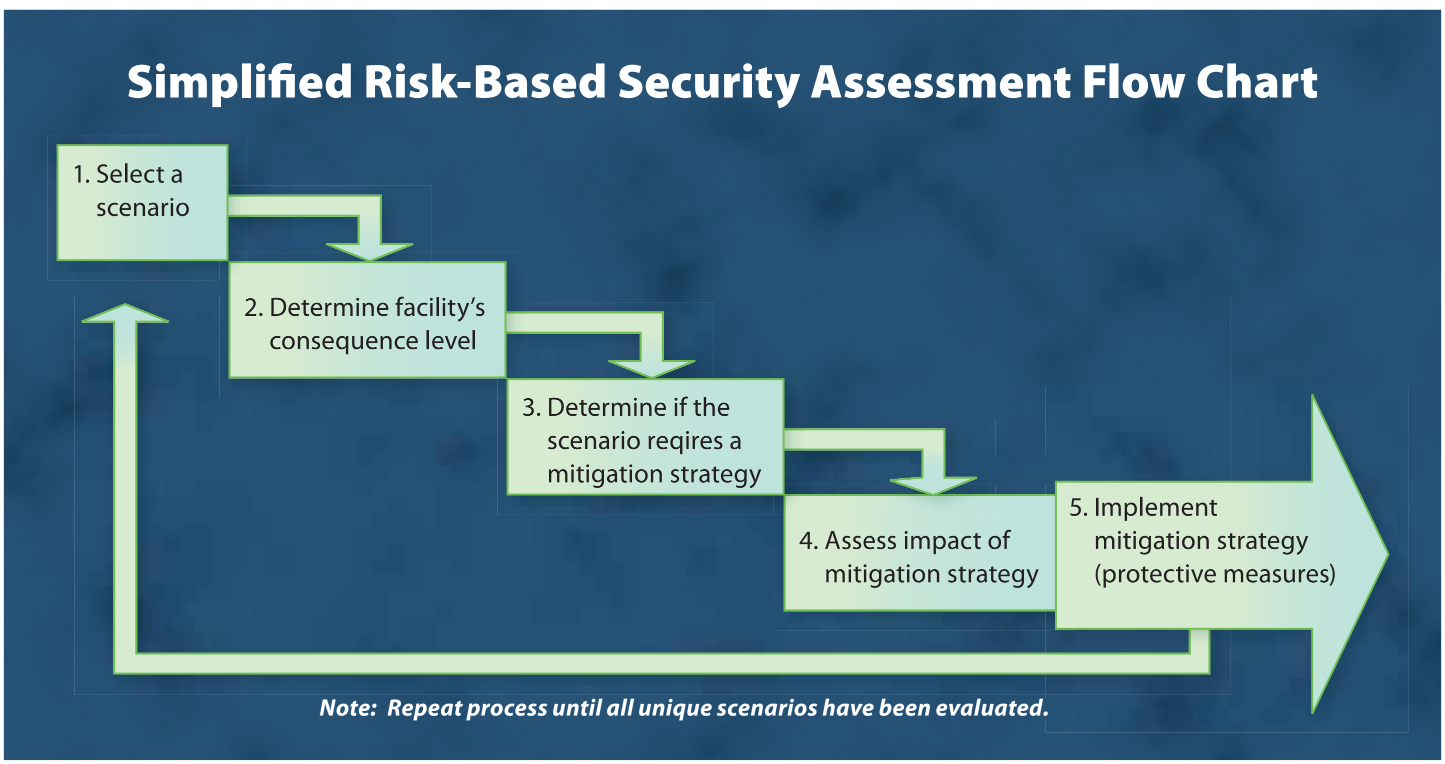
Ship and Port Facility Security (ISPS) Code, adopted by the IMO in December 2002, work hand in hand supporting maritime security around the world to combat acts of terrorism and piracy. Both maritime security regimes contribute to effective protection against a wide range of threats including piracy, stowaways, smuggling, hijacking, theft, and willful damage. Many parts of these two regulatory codes are the same, word for word, and both were enacted to protect vessels, ports, waterways, and seafarers worldwide. The key principles of the ISPS Code are access control, control of restricted areas, the secure handling of cargo, delivery of stores/supplies to a vessel, security monitoring, security policies and procedures, and security training and exercises.

The ISPS Code does not specify measures that each port facility and ship must take to ensure their safety from terrorism because of the many different types, sizes, and business models of these vessels and facilities. Instead it outlines "a standardized, consistent framework for evaluating risk, enabling governments to offset changes in threat with changes in vulnerability for ships and port facilities." For ships, the framework includes requirements for ship security plans, ship security officers, company security officers, and certain onboard equipment. For port facilities, the requirements include port facility security plans, port facility security officers, and certain security equipment. In addition, the requirements for ships and port facilities include monitoring and controlling access, monitoring the activities of people and cargo, and ensuring security communications are readily available.

The MTSA directs the secretary of the department to which the Coast Guard is assigned to assess the effectiveness of anti-terrorism measures implemented in foreign ports from which U.S. flag and foreign vessels depart on voyages to the U.S., as well as any other foreign port the secretary believes poses a security risk to international maritime commerce bound for the U.S. Hence, the Coast

Criteria considered when selecting foreign port assessments:

- **The number of vessels that arrive in the U.S. from that country**
- **The amount and type of cargo being shipped**
- **Economic criticality of the cargo to the U.S.**
- **Threat manifested in the port state**
- **Size of the country's flag state fleet**
- **Its port state control detention history**



The Vessel Security Assessment is essential to developing the Vessel Security Plan. At the direction of the vessel owner/operator, it is the duty of the company security officer to ensure a Vessel Security Assessment is carried out for each vessel in the company's fleet.

Guard created the International Port Security (IPS) Program in 2004 to accomplish this task. The IPS program aligns the domestic MTSA regulations with the requirements of the IMO's ISPS Code. This alignment helped domestic and international maritime stakeholders to better understand how each country and their ports implement maritime security measures through an exchange of good ideas and best practices information.

In order to develop a widely acceptable process that incorporates current information, intelligence, and best practices, the Coast Guard developed a selection matrix and survey protocol that drew on the experience acquired during the development of threat level assessments in U.S. mega-ports. Criteria were used to determine which countries would be visited and assessed, as well as, the timing for visits. All countries that export cargo bound for the U.S. or service vessels departing for U.S. ports would be considered for an in-country visit. A methodology was developed to assist in determining the priority for a port visit.

The Coast Guard provides a security zone for a shipment of liquefied natural gas to Cove Point, Maryland. U.S. Coast Guard photo by Petty Officer Donnie Brzuska.

U. S. Facility and Vessel Vulnerability Assessments

Using risk-based methodology, all regulated vessel and facility owners and/or operators must conduct in-depth performance based security assessments of their operations to identify security weaknesses and vulnerabilities. Risk-based decision-making is one of the best tools to assess security and determine appropriate security measures for a vessel or facility. Risk-based decision-making is a systematic and analytical process that measures the likelihood a security breach will endanger an asset, an individual, or a function and identify actions that will reduce the vulnerability to, and mitigate the consequences of, a security breach or TSI.

For example, a security assessment might reveal weaknesses in an organization's security systems or unprotected access points like the facility's perimeter not being illuminated or gates not being secured or monitored after hours. To mitigate these vulnerabilities, a facility would implement procedures to ensure access points are observable, secured, and monitored by security patrols or closed circuit television. Another security enhancement might be to place locking mechanisms and/or wire mesh on doors and windows that provide access to restricted areas to prevent unauthorized personnel from entering.

The Security Assessment and on-scene security survey should be documented and retained by the Company Security Officer.

Vessel/Facility Security Assessment

The Vessel/Facility Security Assessment includes an on-scene security survey and at least the following elements:

- **Identification of existing security and response measures, procedures, and operations**
- **Identification and evaluation of key vessel operations, including sensitive areas that should be designated as restricted areas**
- **Identification of possible threats to the vessel/facility and the likelihood of their occurrence, in order to establish and prioritize security measures**
- **Identification of weaknesses or vulnerabilities on the vessel/facility, including human factors in the infrastructure, policies and procedures**

Facility/Vessel Security Plans

The vessel and facility security plans are the backbone of the MTSA of 2002. The MTSA calls for a series of plans at the national, port, and individual vessel/facility level. This concept was already working well for oil spill response. It also was being used to increase the MTSA awareness throughout the maritime community to coordinate information and deal with potential threats. Vessels and facilities that take part in certain cargo or passenger activities must have individual security plans that address fundamental security measures such as access control, communications, the establishment of secured areas, cargo-handling or passenger monitoring, personnel training, and incident reporting. The Coast Guard maintains security oversight for 2,777 facilities and 13,500 vessels which must maintain and implement approved plans.

The Coast Guard maintains security oversight for 2,777 facilities and 13,500 vessels.

Before a plan is developed, though, each vessel or facility must complete an assessment of the security vulnerabilities specific to the operation. Based on the vulnerability assessment results, a vessel or facility security plan is developed to mitigate the weaknesses identified. The MTSA regulations also require that security plans include information on the qualifications and/or training necessary for all those who have security responsibilities onboard a vessel or at a facility. Vessels and facilities also must keep certain security-related records available to Coast Guard inspectors, as part of an annual inspection or spot check. The owners or operators of MTSA regulated facilities or vessels must make sure their personnel engage in drills and exercises so they are fully aware of their security responsibilities, particularly in times of crisis. Most important, security plans must list the preventative measures to be implemented to deter unauthorized access to the vessel or facility, security measures for protecting secured areas such as the bridge/pilot house or engine room on a vessel, and cargo storage areas and electrical systems for facilities. Security plans must also outline measures for the safe handling of cargo and ships stores, and for bunkering procedures.

The Coast Guard performs announced and unannounced inspections annually to determine whether a vessel or facility is in compliance with the requirements of the MTSA regulations. While making sure the facilities and vessels are compliant, the Coast Guard also has the mandate to enable, not impede, maritime commerce. The implementation of the MTSA regulations was clear in seeking a balance between maritime security and the free flow of trade.

In 2016, the Coast Guard completed thousands of security-related MTSA annual examinations and spot checks at regulated facilities and recorded only a .03% non-compliance with the MTSA regulations by facility owners/operators. In some cases, examinations of a facility were

Coast Guard personnel conduct a Transportation Worker Identification Credential (TWIC) verification during multi-agency security operations. U.S. Coast Guard photo by Petty Officer Robert Brazzell.

The Goals of Transportation Worker Identification

- To positively identify authorized individuals who require unescorted access to secure areas of the nation's maritime transportation system
- To determine the eligibility of an individual to be authorized unescorted access to secure areas of the maritime transportation system
- To enhance security by ensuring that unauthorized individuals are denied unescorted access to secure areas of the nation's maritime transportation system
- To identify individuals who fail to maintain their eligibility qualifications after being permitted unescorted access to secure areas of the nation's maritime transportation system and revoke the individual's permissions

not conducted due to the facility closing or changing their operations, thus removing them from Coast Guard oversight. The 180 enforcement offenses in 2016 took place at 125 MTSA-regulated facilities and included official letters of warning or administrative civil penalties.

Transportation Worker Identification Credential

Lastly, the MTSA of 2002 directed the Department of Homeland Security to issue regulations to require credentialed merchant mariners and transportation workers seeking unescorted access to secure areas of MTSA-regulated facilities, vessels, and Outer Continental Shelf facilities to undergo a security threat assessment and receive a Transportation Worker Identification Credential (TWIC). Prior to TWIC, specialized facilities with the capability may have chosen to conduct thorough background checks, but there was no standard background check conducted for workers in the nation's ports. The TWIC program carries out the mandate and is an important piece of the layered approach to maritime security in the United States. TWIC is jointly managed by the Transportation Security Administration (TSA) and the U.S. Coast Guard, where TSA is responsible for enrollments, security threat assessments, credential production, and systems operations. The U.S. Coast Guard is responsible for establishing and enforcing access control requirements for MTSA-regulated vessels and facilities. TSA has processed more than 4.2 million enrollments since the program's October 2007 inception.

TSA has processed more than 4.2 million TWIC enrollments since October 2007.

TWICs are tamper-resistant, biometrically enabled identification documents issued to credential merchant mariners operating onboard MTSA regulated vessels and facilities and are part of the access control-focused component of the Coast Guard's overall maritime security program. The TWIC program establishes a minimum uniform vetting/threat assessment across the country. It ensures that workers needing routine, unescorted access to secure areas of facilities and vessels have been vetted against a specific list of disqualifying offenses, which includes terrorism associations and criminal convictions. The Coast Guard views the TWIC as an integral component of our nation's layered maritime security system. Further, we see having a common credential as a vital enabler for the future, when risk-based access control decisions and intelligence capabilities will be more mature.

TWICs have a number of overt and covert security features which make them difficult to counterfeit. Coast Guard regulations specify how security personnel can, and should, visually assess the validity of a TWIC. TWIC readers enhance security by providing for additional verification of the validity of the TWIC and of the identity of the owner by using the biometric information embedded in the card. These security features and procedures, when properly employed, provide significant security benefits even without the use of a TWIC reader. As a visual identity badge alone, the card is easily recognized and provides a foundation for access authority determination. Security personnel have a single, consistent credential for comparison that allows them, through visual check alone, to:

- Verify that the credential is not expired
- Verify that the person presenting the credential matches the photo on the card
- Examine specific security features to determine whether the credential is authentic

As part of the MTSA security program, facility inspectors conducted tens of thousands of inspections of TWICs both visually and electronically in 2016, identifying a miniscule number of instances of non-compliance with the TWIC requirements. Additionally, the TWIC reader rule requires owners and operators of certain MTSA regulated vessels and facilities to use electronic readers designed to work with TWICs. The Coast Guard published the TWIC reader rule on August 23, 2016, with a two-year implementation period.

Conclusion

The security approaches discussed here have matured significantly since first being implemented in 2004. Numerous improvements have been made to secure facilities and the cargo received for loading on commercial vessels around the world. Vessels developed security standards for their operations to meet the mandates of their flag states and better protect the interface that occurs between the vessel and a facility during cargo or passenger operations. Even simple identification and vetting of employees and seafarers has improved significantly with the development of the TWIC in the U.S., and similar programs in other countries. Most importantly, all of these measures remain flexible and adaptable to the evolving threat of international terrorism and crime.

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The Maiden Voyage of the Medical Certificate for Merchant Mariner Credentials

by Dr. Laura Torres-Reyes, M.D., M.P.H.
U.S. Coast Guard, National Maritime Center
Medical Evaluations Division Chief

Determining medical fitness of a worker in the transportation industry requires consideration of risks. Whether it's trains, planes, automobiles, or ships, the safety risk of an individual operator is partially dependent upon the likelihood and severity of a disabling human factor in the context of environmental and workplace factors. While the locomotive, airline, and automotive industries have had centuries of safety lessons learned from disasters attributed to human factors, the maritime industry is the relative new kid on the block. Arguably, the earliest account of a maritime disaster singularly attributed to human factors was the sinking of the *White Ship* sailing the English Channel near the coast of Normandy on November 25, 1120.

The incident was attributed to a drunken crew grounding the ship carrying 300 people, including the heir to the English throne. There were only two survivors and the loss was followed by 20 years of civil war over the English crown. Since then there have been a multitude of notorious peacetime maritime disasters, but rarely have investigations focused on the human factor as the cause. The game changed in 2002 when a small towboat sailing the rivers of Oklahoma ran into the pier of an interstate bridge. The tragedy resulted in 14 deaths and property damage of more than $30 million. The subsequent inquiry revealed the probable cause of the incident was the pilot's sudden loss of consciousness. For the first time, public outcry and congressional interest from the tragedy highlighted the concept that ensuring medical fitness of the merchant mariner was paramount to the future safety of the United States Marine Transportation System (MTS).

Illustration by Azar Nasib/Shutterstock.com.

Merchant Mariner Medical Fitness

The United States Coast Guard (USCG), housed within the Department of Homeland Security (DHS), is the government agency charged with providing safety, security, and environmental protection for the MTS. The MTS comprises the navigable waterways and harbors used for movement of commerce, pursuit of recreation, and maintenance of national defense. The MTS also includes the ports, marinas and land-based operations necessary to bring people, goods, and equipment to and from the water, as well as the vessels, individuals, and entities that use the system.

According to the United States Maritime Administration, 99 percent of overseas trade, by volume, travels to and from the U.S. by ship. Moreover, the activities of the MTS contribute more than $649 billion to the nation's annual gross domestic product, providing some 13 million jobs.

Commodities moved by way of the MTS include passengers, food, and manufactured goods. They also include hazardous materials and bulk cargoes such as crude oil, liquid natural gas, petroleum, and coal. When the MTS functions as designed, it promotes U.S. commerce and defense. However, when marine accidents occur they can have devastating effects on public health and the environment.

A critical component of the MTS is the merchant marine workforce, a group of dedicated maritime professionals who are employed on the fleet of marine vessels. As part of its marine safety mission, the USCG establishes the standards for merchant mariner medical fitness, with the objective of ensuring all individuals who are licensed and certified by the agency are healthy and free of medical conditions that might pose a risk to public and maritime safety. A safe and dynamic MTS is of vital importance to the U.S. economy, environment, and national defense. Because of the potential hazards related to movement of commodities and passengers, the individuals who operate and work upon the fleet must meet appropriate professional and medical standards to protect the safety and security of the MTS.

Medical Fitness of Merchant Mariners

While medically related marine accidents are thought to occur infrequently, there may be more cases where a mariner's chronic illness results in death or requires evacuation, or repatriation, while aboard the vessel. Although these cases garner less attention than a maritime accident, they are important to consider because they may create unsafe, stressful conditions for the remaining crew members by leaving the vessel short of critical manpower. Lefkowitz[2] studied cases of mariners who required repatriation due to illness or injury, obtained from the database of a global telemedicine service provider. Researchers identified 3,921 cases of illness or injury at sea during their four-year study period from 2008 to 2011. Of the 1.6 percent who required repatriation, about 62 percent, or 38 seafarers, required evacuation due to medical illness. Gastrointestinal, genitourinary, respiratory, and cardiovascular disorders were the most frequent types of medical illness leading to need for repatriation.

Life aboard a marine vessel poses unique challenges that were considered in the development of the mariner medical regulation. Coast Guard guidance provides that "service on vessels may be arduous and impose unique physical and medical demands on mariners." Additionally, Navigation Vessel and Inspection Circular 04-08, Enclosure (4) directs that "the nature of shipboard life and shipboard operations is such that mariners may be subject to unexpected or emergency response duties associated with vessel, crew, or passenger safety, prevention of pollution, and maritime security at any time while aboard a vessel." Oldenburg, et al. (2010) asserts "seafaring is associated with special mental psychosocial and physical stressors and cannot be compared with jobs ashore."

Mariners may have to live aboard the vessel for extended periods of time without access to definitive medical care. In many cases the vessel's medical officer has only minimal medical training, and medications and supplies may be limited to those needed for first aid. Therefore, medical conditions that are likely to worsen or that require close follow-up with a provider, may not be suitable for issuance of a medical certificate. The regulatory process also considers the environmental stressors faced by mariners aboard the vessel, which include long work hours and work-rest cycles that may cause fatigue and interfere with sleep and rest. Additionally, adverse weather conditions, noise, vibration, and ship motion can increase mariner workload, heighten stress, worsen fatigue, and disturb sleep.

There are also significant physical demands placed on mariners while aboard the vessel including the need to lift and move cargo, as well as the need to participate in emergency and fire-fighting response should the need arise.

Physical requirements can be demanding for merchant mariners. All photos courtesy of the National Maritime Center historical collection.

Mariners with significant physical impairments or those, whose medical conditions cause significant functional impairment, may not be suitable for medical certification.

Fit For Duty

Although not expressly stated within the Coast Guard's regulation or policy documents, the presumed purpose for developing and applying merchant mariner medical standards is to ensure no harm comes to the public or maritime environment as a result of a mariner's medical conditions. Thus, the USCG's interest in the health of the merchant mariner population stems largely from the agency's duty to ensure medical certificates are not granted to individuals whose medical conditions are likely to cause or contribute to marine accidents. Related to this presumption, the Coast Guard's merchant mariner medical standards have come under intense scrutiny over the past 13 years due, in part, to two high-profile marine casualties and the regulatory backlash that followed.

Allision of Staten Island Ferry Andrew J. Barberi

On October 15, 2003, the passenger vessel *Andrew J. Barberi* crashed into the pier of the Staten Island Ferry terminal

Mariners perform maintenance in demanding environments. U.S. Coast Guard National Maritime Center photo.

with 1,500 passengers and 15 crew members on board. Eleven people died and 70 were injured in the accident. Damages exceeded $8 million. The National Transportation Safety Board (NTSB) investigation found, that at the time of the accident, the involved mariner had become suddenly incapacitated for unknown reasons. Their report cited the assistant captain's unexplained incapacitation as one of the probable causes of the accident, and the board recommended the Coast Guard maintain better medical oversight of mariners.

Allision of Containership M/V* Cosco Busan *with the San Francisco-Oakland Bay Bridge

On November 7, 2007, the containership M/V *Cosco Busan* ran into one of the towers supporting the Bay Bridge. The accident ruptured the vessel's fuel tanks and caused the release of more than 53,000 gallons of oil into San Francisco Bay. The spill contaminated 26 miles of shoreline, killed 2,500 birds, and delayed the start of the crabbing season. The cost of the environmental cleanup exceeded $70 million. The NTSB investigation report concluded the accident was caused by the pilot's failure to safely navigate which was due, in part, to his use of impairing prescription medications. Additionally, the board cited the USCG's failure to provide adequate medical oversight as a contributing factor for the accident, and identified deficiencies in the USCG's system of medical oversight for all mariners as an overall safety issue.

Evolution of the Medical Review Process

In the years following the *Cosco Busan* accident, the Coast Guard took steps to increase its medical oversight of the merchant mariner population. The USCG acknowledged that, in a system as critical and complex as the MTS, individual mariner health conditions could precipitate events that pose a significant risk of danger to public health and the environment. The agency also recognized adjustments would be required to better ensure the merchant mariner population was healthy enough to serve safely.

In 2008, the Coast Guard changed its medical evaluation process to provide a more stringent review of merchant mariner medical documentation. Prior to that, mariner medical examinations were reviewed by non-medical personnel, working in various regional Coast Guard offices, called Regional Exam Centers. In 2008, the medical review process was centralized and moved to the Coast Guard's National Maritime Center (NMC) in West Virginia. Under the new process, specially trained medical personnel at the NMC review all medical documentation submitted by mariners. The purpose of centralization was to ensure medical evaluations were conducted in a consistent manner, and that mariner applicants who are granted a license are "safe to work in a safety-sensitive position."

Unfortunately, the USCG did not anticipate that the new process would lead to an increase in the numbers of mariner applicants turned down for medical reasons. As it turned out, the process of increased medical scrutiny resulted in a dramatic increase in the number of mariner applicants who were denied the ability to work because of their medical conditions. While fewer than 0.6 percent of mariner applicants, or 500 individuals, were denied medical certification in calendar year 2009, the percentage more than quadrupled to 2.6 percent, or 1,676 applicants, in 2011. Information on the number of mariner applicants whose applications were denied for medical reasons prior to year 2009 is not available.

Marine Engineers' Beneficial Association member 'Big' Ed Eastlack on the LMSR *Shughart*. U.S. Coast Guard National Maritime Center photo.

Whether the increased denial rate resulted from improved oversight or overly stringent regulation, remains a matter of debate. Many voiced concern that the Coast Guard's medical evaluation process was overly rigorous. At a July 2009 hearing before the committee on Coast Guard and Maritime Transportation, a subcommittee of the Committee on Transportation and Infrastructure, House of Representatives, industry representatives stated the Coast Guard's evaluation process caused unacceptable delays, kept mariners out of work, and caused unnecessary interference with commerce. The increased stringency may have been successful in removing some mariners with serious health conditions from service, but, it is not clear the process had a positive impact on the overall health of the mariner population, though it certainly induced fear and concern among many mariners.

There is no question about the need to deny a medical certificate for a mariner applicant whose medical condition truly poses a public safety risk that can prevent harm to crew, passengers, public, and the environment. However, if the regulations and policy governing mariner medical fitness exceed what is reasonably required for the protection of public safety, then the agency's efforts may needlessly deny a mariner the right to work in his/her chosen profession. Moreover, fear of job loss created by unreasonable medical regulations may drive mariners to avoid medical care just to prevent detection of a condition that could lead to loss of medical certification. The ultimate goal is to strike a balance between medical regulation and policy to prevent adverse health effects on the merchant mariner population and decrease the risk of harm to public health and environmental safety.

Personal protective equipment is essential to mariner safety. U.S. Coast Guard National Maritime Center photo.

Current State

The current process for a mariner to obtain a medical certificate is separate from the process to obtain a merchant mariner credential. To start the process, mariners fill out Form 719K, Application for Merchant Mariner Medical Certificate or the Form 719 K/E, Application for Merchant Mariner Medical Certificate For Entry Level Ratings. The medical evaluation program for mariners is considered an "open" system in that mariners can choose any medical provider—physician, physician assistant or nurse practitioner—to perform the required physical examination and complete the application. The mariner then submits the application and required documentation to one of the Coast Guard's 17 Regional Examination Centers (RECs) for preliminary review. Once the REC completes its review, the application is forwarded to the Medical Evaluation Division at the NMC, which is solely responsible for ensuring a medical certificate is efficiently provided to qualified mariners.

The National Maritime Center measures the success of the current medical certification process by the metric of Net Processing Time (NPT). The NPT is the total time the Coast Guard spends processing the application, from receipt to issuance of certificate, and does not include the time waiting for information from mariners, denials, or appeals. The Medical Evaluation Division's goal for NPT is less than 20 days. By the end of January 2017, the NPT had reached an all-time low of 8.49 days, with 97 percent of the certificates being produced within the 20 day goal.

On the Horizon

There is no question that standardization of processes and creation of a stable workforce at the NMC has vastly improved the quality and consistency of the centralized evaluation. Further areas for process improvement clearly point to the need for training and guidance to medical providers performing the actual physical examinations. The quality of the physical examinations performed is highly variable and the recognition that supporting documentation is needed for significant health conditions is virtually non-existent by the majority of providers performing these examinations. Requesting additional medical information from the providers who perform mariner medical fitness

Key Functions Performed by the Medical Evaluation Division

- **Certified Medical Assistants review every 719K or K/E that arrives in the medical division. Although unable to grant waivers, they are able to process more than 70 percent of the daily mariner files received where no further review is required.**
- **Medical evaluators review the 719Ks that require a more comprehensive review due to medications, injuries, illness, or a significant medical history.**
- **Medical evaluators have the ability to grant waivers. They can also request additional information if not enough documentation has been provided to allow them to make a determination.**
- **When a medical evaluator has determined the mariner may NOT be fit for medical certification, the file is submitted to the division chief, an Occupational Medicine physician, for final determination. Fewer than 2 percent of all 719Ks sent for final level review are found not fit for medical certification.**
- **All 719K applications recommended for denial are submitted to the Division Chief for final approval/denial.**

evaluations is necessary for almost 10 percent of applications seen in the medical division. The end result is delays in processing while awaiting the submission of additional mariner medical information. Additionally, physical exams performed by medical providers not familiar with the physical demands on merchant marines have been identified by international colleagues as a significant weakness in our program. Trained providers are considered standard practice for medical credentialing programs in countries such as Canada and Great Britain.

In 2015, reform of the merchant mariner medical certification process was mandated by the Congressional Coast Guard Authorization Act, Sec. 309 (P.L. 114-120). It defines the creation of a Designated Medical Examiner Program (DMEP) that includes a "trusted agent" who may issue a medical certificate to qualified mariners. The development of a DMEP will allow the Coast Guard to improve partnerships with industry stakeholders while simultaneously serving the mission of the Coast Guard and the National Maritime Center. Development of this program will improve communications between stakeholders, the quality of submitted examinations, and contribute to overall improvement in medical fitness determinations. The proper balance of prevention, mariner safety, and health will continue to guide improvements to this robust program for the diverse workforce of dedicated merchant mariners. The journey continues.

Color vision and visual acuity requirements are important to mariner safety. U.S. Coast Guard National Maritime Center photo.

About the author:

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Endnotes:

1. Significant sections of this article are from an unpublished document by my colleague Dr. Adrienne Buggs at the U.S. Coast Guard, Office of Merchant Mariner Credentialing. Her Master of Public Health thesis "Through the Looking Glass: A Critical Analysis of the Coast Guard's Process for Regulating Merchant Mariner Health," provides an excellent synopsis of the influences that shaped the development of merchant mariner medical policy, and identifies opportunities to enhance the U.S. Coast Guard's use of public health strategies to promote the health of the merchant mariner population.
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Addressing the Challenges of Cyber Security

Sector New York works to build beneficial relationships

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The economic vitality and national security of the United States depends on a vast array of interdependent and critical networks, systems, services, and resources that constitute, in part, cyber space. It's far too easy to take for granted how we communicate, travel, power our homes, bank, run our economy, and manage our integration into the larger "cyber ecosystem." To better understand future implications and challenges for the Coast Guard and the marine transportation system (MTS), *writ large,* Sector New York developed a cyber program with three main goals:

- Increase corporate knowledge of cyber security efforts within the Port of New York and vessels calling on the port complex.
- Partner with world-class entities to look for the "best-in-class" cyber practices, then evaluate and harvest those concepts that show promise for applicability to the broader MTS.
- Develop an exercise system that tests and evaluates cyber resiliency, just as we would prepare to respond to any other reasonably likely scenario with the potential to produce severe consequences.

As an operational commander considering where and how best to invest effort, the calculus of risk management makes it essential to consider both the impacts and return on investment in the allocation of scarce resources. It would be relatively easy and benign to wait for somebody else to frame the cyber issues. As U.S. Coast Guard Commandant Admiral Paul Zukunft pointed out at a Center for Strategic and International Studies (CSIS) forum in Washington, D.C., on June 17, 2015, if government agencies can share best practices and establish voluntary standards in cyber security, then enlightened self-interest will prompt private companies to adopt them.[1] Discussing cyber vulnerabilities and how a cooperative cyber engagement strategy may mitigate them and allow for a quicker response has been deemed a worthwhile investment.

Cyber Discipline Tiger Team Discovery Lead Chief Warrant Officer Steven A. Chipman inspects a network router box at Coast Guard Finance Center. Checking for vulnerabilities, Tiger Teams are inspecting, testing and scanning the security of all web-based interfaces and applications interfacing the Coast Guard unclassified network to bring units into compliance. U.S. Coast Guard photo by Senior Chief Petty Officer Sarah B. Foster.

Yogi Berra once famously opined that "The future ain't what it used to be." So, too, the future of cyber security won't be what it is today. The only foreseeable constant is that it will likely remain difficult to accurately define; it will potentially be unbounded, as cyber intersects across virtually all aspects of politics, society, and the economy, among other aspects of everyday life.

We urge each of you reading this article to consider what resources you have available and how you might contribute to the larger dialogue as we think about the future. The cyber issue is not going away—if anything, the challenges will follow an exponential curve as technologies and threats evolve. That makes it an imperative for each of us to continue to understand the threats and mitigate their impacts so we can learn how to better operate within the cyber ecosystem.

Coast Guard Information Systems Technicians are responsible for establishing and maintaining Coast Guard computer systems, analog and digital voice systems—telephones and voicemail—and installing and maintaining the physical network infrastructure that ties the systems together. U.S. Coast Guard photo by Petty Officer Etta Smith.

High Stakes, High Regard

According to the Lloyd's (of London) City Risk Index, cyber attacks outweigh physical terrorism in the amount of gross domestic product (GDP) at risk: $294.15 billion, compared to $98.2 billion. Of the 301 cities analyzed worldwide, New York ranked number one at risk for loss of GDP by way of cyber attack, with a potential vulnerability of $14.08 billion.[2]

The U.S. Coast Guard released its national cyber strategy in June 2015 to emphasize the importance of making cyber security a critical operational domain. As a result, Sector New York and its industry port partners have elevated cyber security to the highest level of importance. Elevating cyber defense culture and status in this regard is the first line of defense in reducing the vulnerability public and private entities face. Information, operations, and public perception are all equally at risk. However, the development and collaboration surrounding pertinent cyber security protocols within the MTS remains limited.

Port Partner Outreach—and Beyond

In a completely voluntary environment, Sector New York started the conversation by inviting MTS port partners, port operators, critical infrastructure/utility personnel, local and federal authorities, academia, and various subject matter experts from dissimilar institutions to discuss potential cyber risks within the maritime domain.

In an unusual move, we also reached out to representatives of the financial services industry. It's really not that strange, though, considering the current state of cyber security and which market segment best epitomizes the need for it. Taking advantage of their close proximity, Sector New York reached out to Wall Street firms to help shape the cyber narrative. The ability to partner with non-traditional Coast Guard actors like Goldman Sachs, Con Edison, NASDAQ, and American Express, as well as the robust maritime port community, enabled us to make a more comprehensive and nuanced assessment of cyber vulnerabilities, informing us about what to expect in terms of various market segment response posture.

Leveraging the Coast Guard's Area Maritime Security Committee (AMSC), Sector New York laid the foundation to facilitate quarterly, semi-annual, and annual meetings to bolster awareness of cyber issues within the port. The beginning phase of these meetings helped establish proper personnel, definitions, and common understandings pertaining to vulnerabilities from an industry perspective.

Cyber Security Subcommittee and Liaison Program

Executing these meetings under the umbrella of the AMSC, Sector New York developed the nation's first regional-level cyber security subcommittee. This subcommittee strives to identify opportunities for MTS port partners to share information and work in an environment of training and learning. As a result, cyber security measures are hardened, new threat analyses are developed, and time and money are saved.

Through the AMSC cyber security subcommittee and the MTS port partner/USCG relationship, Sector New York established a cyber security liaison outreach program under the commandant's strategy to "leverage partnerships to build knowledge, resource capacity, and an understanding of MTS cyber vulnerabilities." The Cyber Security Liaison Program consists of a member of the local Coast Guard unit, dressed in civilian business attire, meeting with facility security officers and information technology (IT) management to conduct an overview of a respective business from management and operational perspectives.

Once a liaison officer achieves a relative understanding of the business' cyber operations, he or she begins an in-depth cyber security conversation with IT management. The officer directs the discussion toward learning IT and industry best practices to identify common ideas and perspectives on cyber defense within the industry. These conversations have become especially beneficial to understanding what each terminal or agency identifies as the most important cyber security vulnerabilities.

Coast Guard Commandant Admiral Paul Zukunft participates in the May 2016 opening meetings held at Con Edison with foundational members from the Area Maritime Security Committee's Cyber Security Subcommittee. U.S. Coast Guard photo

The Cyber Security Liaison Program also has provided company anonymity. The Coast Guard meets with MTS port partners in their offices or agency offices—as their cyber protocol allows—to openly discuss a normally sensitive/guarded topic. This offers a comfortable environment for operations and management to discuss currently unregulated and publicly sensitive items within the company's cyber program.

Key Players

Sector New York has included its parent units, the First Coast Guard District and Coast Guard headquarters, to bolster the cyber security discussion within the port. In May 2016, Admiral Paul Zukunft and members of his staff were the keynote guests at the first cyber security luncheon hosted by the AMSC cyber security subcommittee. In conjunction with Con Edison, Sector New York hosted two separate meetings with the commandant at this event.

The first meeting consisted of roughly 20–25 influential partners within the Port of New York/New Jersey. This provided an intimate environment with the commandant and lead USCG cyber security staff officers. Questions and conversations revolved around Coast Guard cyber security involvement in public and private industry, law enforcement, budgeting, and advancement for educational institutions. The second meeting was a luncheon that involved more than 90 vital maritime port partners engaging in an open-forum Q&A discussion on how and what the Coast Guard's role should be within the cyber realm.

This was an impressive turnout for an AMSC cyber security subcommittee event, which further highlighted the community's concern surrounding this issue. Sector New York's ability to get the most influential leaders from the Port of New York/New Jersey under one roof to focus on maritime cyber security and provide Coast Guard leadership with real concerns and issues demonstrated a high level of port-wide buy-in toward defending against cyber breaches.

Sector New York has devoted itself to championing a cohesive cyber security subcommittee, developing a strong foundation through the unit's area maritime security committee. The ability to get the right people in the same room to ask very difficult questions regarding cyber security has given local experts the capability to put theoretical discussions into physical practice. The subcommittee has notably been able to leverage partners from MTS ports, academia, companies from separate industries with more robust and articulated cyber programs—financial institutions and utility companies among them—and local state and federal authorities such as the New York Police Department, New Jersey State Department of Homeland Security, and the Federal Bureau of Investigation.

Tabletop Exercise "Cyber Intrusion"

Most recently, Sector New York and the cyber security subcommittee continued its outreach to port partners through the Coast Guard Exercise Support Team.

Coast Guard Sector New York Deputy Commander Captain Thomas Morkan delivers opening remarks at the August 2016 cyber security tabletop exercise held at the Stevens Institute of Technology in Hoboken, New Jersey. U.S. Coast Guard photo

The exercise support team specializes in developing potential workshops, tabletop exercises, and eventual full-scale exercises to simulate cyber vulnerabilities. In addition, the team sets a foundation for positive communications between industry partners and the authorities that would provide aid in the event of a marine transportation system cyber compromise.

The tabletop exercise "Cyber Intrusion" was brought to life in August 2016. Developed by the AMSC cyber security subcommittee, USCG Exercise Support Team, Stevens Institute of Technology's Maritime Security Center, Louisiana State University–Stephenson Disaster Management Institute, and the New Jersey Office of Homeland Security and Preparedness, the exercise focused on hypothetical cyber scenarios, with an emphasis on discussing realistic reactions and expectations in the event of a cyber attack.

Day one was held at the Stevens Institute of Technology in Hoboken, New Jersey, and hosted more than 60 participants from oil and gas terminal operations. Day two was held at Maher Terminals in Elizabeth, New Jersey, and hosted over 60 participants from container terminal operations. Day three was held at the New York City Office of Emergency Management, and hosted more than 50 participants from passenger and ferry operations.

Many private companies were initially guarded, unwilling to openly discuss their proprietary business operations and true vulnerabilities. But once they realized the benefits of combating cyber threats as a community, the exercise began to stimulate discussions for best practices, the domino effects of a cyber breach, training scenarios, possibilities for grant funding, avenues for information sharing, and eventual investigations and prosecutions against cyber offenders. Overall, participants finished the exercise feeling encouraged to discuss the unknown and unregulated side of cyber security, pledging to play a larger role in the development of cyber security within the port.

Cyber Defense and Cyber Posture Lessons Learned

Through the cyber security subcommittee's extensive commitment, consistency, and hard work, Sector New York has gained a greater understanding of the cyber environment within the MTS. The broad spectrum of cyber defenses range from large, multi-national corporations with dedicated staff and resources to the smaller, privately owned operators who treat cyber security as more of a collateral duty.

One challenge within the port community is the threat of information theft. Larger companies are often able to allocate a greater budget for the more highly sophisticated, intricate cyber postures they employ, as well as abundant resources to protect their information. When these large corporations interact with and share this protected information with smaller port operators as part of their normal business practices, the smaller companies may not have the same level of cyber protocols and defense, which could leave such highly valuable information more susceptible to theft.

Another challenge is communication. A large percentage of MTS port partners understand that cyber security is increasingly critical, with definite vulnerabilities. However, the communication among private port partners is limited.

In the event of a cyber breach, for example, affected organizations may be reluctant to report it to authorities for fear it may negatively affect their business operations, reputation, or stock value. The distress of hurting the company's public perception and bottom line is the main concern for all parties involved. Some larger MTS port partners tend to focus on rectifying the breach internally and resuming operations as soon as possible rather than reporting a cyber security breach to the public or the appropriate authorities. The fear of being labeled as a company that has been "hacked" often outweighs the benefit of reporting potentially helpful information to authorities.

Though growth is limited, more MTS port partners are making cyber security education a priority, and their knowledge and understanding of standards at other companies and institutions is beginning to expand.

Information Technology Lessons Learned

In spite of their pride in the industry's blue collar, physical roots, those employed in the maritime domain must interact with the technology that makes it possible to keep up with today's demanding business world. The mariners, longshoremen, truck drivers, and terminal operators cannot bypass the applications and devices integrated into daily terminal operations. These operations and workers act as the hands to the logistical mind for getting a container from origin to destination in preparation for the holiday inventory, for the 300,000 barrels of oil imported every other day from the Middle East to fuel our economy, or to a ferry system that transports 60 million commuters around the New York metro area every year.

The "all-in-one" approach is common for handling our MTS port partners' IT divisions and staffing issues. Their funding, staffing, and locations are often set up to share responsibilities within a single IT staff. Current cyber postures allow them to maintain a help desk or hotline for immediate IT help, network and hardware set-up for physical equipment, and analytics of cyber threats. In reality, this is merely ciphering through potential cyber threats and deciding whether or not they are legitimate contacts, emails, or files. These problems and questions are often assigned to one staff under one roof.

Our counterparts at top financial institutions, considered the industry standard when it comes to cyber security, do not have a "one-stop" IT shop. These branches within the IT staff—help desk/hotline, network and hardware set-up, cyber defense—are segmented and responsible for their own area of expertise.

In fact, the cyber defense branch is further segmented to augment investigation and response in the areas of cyber defense and cyber forensics. The cyber defense division focuses on hardening the company's cyber posture and strengthening its preventative measures. The cyber forensics division concentrates on analyzing incoming threats and breaches, where the threats came from, what the threats were seeking, potential dwell time, and other various informative trends.

What we also find vital to the citadel of cyber security for our financial institutions are some essential information technology practices and processes. Though they may not apply to the overall demands of the maritime domain, understanding the financial industry's tactics in cyber security can better inform the maritime industry in building its own fortress and standards for cyber security. These introductory practices and processes implemented by a wide number of financial firms have much in common with the practices implemented by the Coast Guard for incident response—a process very familiar to the Coast Guard's port partners. The process of identification, coordination, response, and resolution can be directly correlated to the cyber domain. In broad strokes, port partners from the maritime domain can use these four foundational practices to better harden their own cyber security programs.

Next Steps

Through the AMSC cyber security subcommittee's implementation, the cyber security conversation has begun among Port of New York/New Jersey MTS port partners.

Continuing this open line of communication by way of CG Homeport pushing constant information and bulletins, regularly scheduled meetings, and hosting various workshops and tabletop exercises led to a successful two-day Cyber Game & Workshop held in Brooklyn, NY on August 15th and 16th, 2017. Approximately 65 participants each day represented over 50 different public and private sector organizations from the Port of New York/New Jersey.

Day one's Cyber Game provided a venue for discussion, training, and competition aimed at better informing port partners of the current vulnerabilities that lie within cyber security and the MTS. To participate, entities were requested to bring one "Cyber Technician" for technical assistance, and one "Decision Maker" for holistic assessments with a business perspective.

The Cyber Game identified top functions, services or assets, and potential adversaries as well as a hypothetical "Red Team" vs. "Blue Team" timeline to develop threats and cautionary reactions.

Financial Foundations: Four Principles for Cyber Security

1. **Identification—Understand what equipment and application programs are most vulnerable.**
2. **Coordination—Ensure the equipment and programs running the maritime operations are up-to-date.**
3. **Response—Limit the exposure and vulnerability of the greatest risk: the end user.**
4. **Resolution—Promote awareness and education throughout the industry for a higher standard of cyber hygiene.**

During the Cyber Game, participants conducted risk assessments to identify the port's most critical cyber infrastructure. The game highlighted the interconnectivity of the port, the potential cascading effects of a cyber breach, and the resultant importance of collaboration in responding to cyber threats, setting the stage for the workshop on day two.

Various presenters across the public and private sector presented information on the following topics during the workshop:

- Legal Issues and Ramifications of Cyber Breaches/Attacks within the Maritime Domain,
- Current State of the Maritime Cyber Security Landscape,

- Vulnerability Management, Risk Assessment, and IT Systems Improvement,
- Exercise Methodology and Available Exercise Tools, and
- Operational Technologies Systems Improvement.

The two-day event highlighted two important themes: First, cyber security requires collaboration. Because of the interconnected nature of the port, cyber resilience must be a shared goal.

Second, to respond to the cyber threat, we should shift the discussion from "cyber security" to "cyber risk management." Threats come in all forms, from individual hackers, to foreign governments, to outdated technology and to employees with poor "cyber hygiene." With such a diverse set of threats, we may not be able to reach absolute cyber security. We can, however, conduct risk and vulnerability assessments, quantify our risk, focus on our critical infrastructure, and take responsible steps to mitigate and respond to threats.

Importantly, concluding the two-day event, participants were willing and eager to collaborate by sharing vital information on cyber threats, and to work together to produce regional-level guidance on cyber security best practices as part of a continuing effort to make the Port of New York and New Jersey more cyber resilient. This was a positive shift in attitude compared to just a year before.

The AMSC cyber security subcommittee will continue to promote the ideas and lessons learned from its commandant luncheon, tabletop exercise "Cyber Intrusion," and continued interaction with port partners through the Cyber Security Liaison Project. These ideas and lessons learned have been shared with MTS port partners as well as local, state, and federal authorities.

For our MTS port partners, the ideas and lessons learned include using and bolstering the Maritime Information Sharing Analysis Center, continuing to gain company buy-in for sharing information amongst industry partners, and educating port partners on the use of FBI Infraguard/Cyberhood, an FBI forum for cyber attack reporting and analysis. This integration with FBI capabilities will help to push vital notifications and more efficiently engage in investigations in the event of a cyber breach, leading to a potential increase in the prosecution of cyber offenders.

For local, state, and federal authorities, the ideas and lessons learned deal heavily with the sensitivity and discretion demonstrated in information reporting. As a bridge between industry and government, the AMSC cyber security subcommittee stresses to similar Port of New York/New Jersey law enforcement entities an understanding that detailed information sharing is detrimental to a company's bottom line and stock prices.

The sharing of a company's name, specific data stolen, or any association with the label "hacked" can cripple a company. The lack of discretion in gathering and dispersing self-reported information will deter companies from reporting breaches and defeat the purpose of information sharing. Sector New York aims to foster productive information sharing and encourage self-reporting in the event of a possible cyber breach.

Conclusion

Coast Guard Sector New York has embraced its role within the cyber ecosystem through the professional relationships it has forged through its AMSC cyber security subcommittee and the numerous resources it has developed outside of typical maritime actors.

We will strive to increase corporate knowledge of cyber security efforts within the Port of New York/New Jersey and the vessels calling on its port complexes, and partner with world-class entities to look for the "best in class" cyber practices. We will evaluate and harvest the concepts that show promise for applicability to the broader MTS. We will develop an exercise system that tests and evaluates cyber resiliency. We will do this as part of Sector New York's ever-evolving mission to better understand future implications and challenges for the Coast Guard and the MTS in this rapidly evolving cyber domain.

Our success in achieving these three main goals will depend upon the adaptability of the men and women engaged in the larger dialogue. This cyber issue and the steps we take to operate within, understand, and mitigate impacts to the cyber ecosystem begin with a forward-leaning Coast Guard that is engaged and leveraging its unique role in the maritime industry.

Sector New York has heavily committed to gaining a better understanding of cyber challenges, and the return in terms of knowledge and new partnerships has proven to be a worthwhile investment.

About the Authors:

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LT Chad Ray serves as a supplement to the contingency planning department while assigned to Sector New York's prevention department. He graduated from the U.S. Merchant Marine Academy, earning his Bachelor of Science in logistics and intermodal transportation, and is a licensed second mate.

Endnotes:

1. http://breakingdefense.com/2015/06/adm-zukunft-unveils-new-coast-guard-cyber-strategy/
2. Cambridge Centre for Risk Studies at the University of Cambridge Judge Business School, Lloyd's City Risk Index 2015-2025, www.lloyds.com/cityriskindex/. (Accessed August 1, 2016).

Improving Deep Water Ocean Drilling Safety and Operations

Response to *Deepwater Horizon*

by Mr. James Rocco
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On April 20, 2010, the crew of the mobile offshore drilling unit (MODU) *Deepwater Horizon* was in the final phases of temporarily plugging the Macondo well in the Gulf of Mexico so they could move the rig on to her next assignment.

In the course of the operation, flammable gases travelled from the well head up about 5,000 feet of pipe to the rig and ignited. Well control efforts could not stop the flow, explosions occurred, and fires raged to the point that the rig had to be evacuated. Eleven of the 126 crew members on board did not survive. Two days later, the unit sank to the bottom of the ocean.

In order to meet the evolving demands of accessing deeper, higher-pressure reservoirs in ever deeper waters, the global industry responded by broadening the suite of MODU types.

What is a MODU?

The earliest MODUs, quite simply, consisted of a drilling derrick and other associated equipment installed on a barge, allowing these units to be brought to an offshore location to perform the required work. The limitations of these pioneering units quickly became apparent. In order to meet the evolving demands of accessing deeper, higher-pressure reservoirs in ever deeper waters, the global industry responded by broadening the suite of MODU types.

The last 60-plus years have arguably been witness to advances in offshore drilling paralleling the advances in computing and communication technologies over this same period. In 1954, the first purpose-built mobile offshore drilling unit was deployed in 40 feet of water. As technology has advanced, the latest of these specialized units are capable of drilling wells in water depths greater than 12,000 feet and extending to a total depth (TD) in excess of 35,000 feet below the seafloor.

Additionally, as offshore drilling technology has progressed, the types of MODUs have expanded to satisfy a demanding variety of operating environments. Weather, water depth, oil and gas reservoir characteristics, and economics are just a few of the many considerations made in determining the right MODU type for any particular drilling project.

MODUs are typically owned and operated by drilling contractors and leased to oil exploration and development companies to perform drilling operations on their behalf. In addition to drilling activity, the MODU may be used to perform a variety of other tasks, often with other specialized contractors, to ensure a well is made ready to produce the oil and gas from the reservoir. This process may include "temporary abandonment," where the well bore is safely plugged with the intention to reenter and produce the well in the future when the oil company chooses to install surface and/or subsea equipment and facilities to begin production.

The Semisubmersible *Deepwater Horizon*

In 2010, the crew of the semisubmersible *Deepwater Horizon* had just completed drilling the Macondo well to its target depth. In order to temporarily abandon the well, they

MODUs Commonly Used Today

- **Submersibles—These units are submerged to rest on the seabed, with the working deck remaining above water prior to beginning drilling activities; they have very limited water depths.**
- **Semisubmersible—These units have a specialized hull form that allows for efficient movement between operating locations. Upon reaching the operating location, the unit is submerged to a more stable operating draft. They may be anchored or dynamically positioned while conducting drilling activities and can operate in a wide variety of water depths.**

Semisubmersible oil rig, the *West Orion (6th generation).* Photo courtesy of Seabed.

The Transocean drill ship *Discoverer Inspiration* (foreground) was involved in the *Deepwater Horizon* response. U.S. Coast Guard photo by Petty Officer Jonathan Caruk.

- **Jackup—A barge-type structure typically supported by three legs that extend to the seabed to "jack up" the hull structure out of the water to provide a stable work platform; limited to a depth of 450 feet of water, or less.**

A jackup oil rig, the *Sail Mobile,* in the Gulf of Mexico, just off the coast of Mobile, Alabama. U.S. Coast Guard photo by Petty Officer Chad Saylor.

- **Drill Ship—A "shipshape" vessel with the derrick and drilling equipment installed amidships and typically held in position via dynamic positioning systems. They can operate in a wide variety of water depths.**

Drill ship oil rig, the *West Tellus.* Photo courtesy of Seabed.

placed a cement plug to isolate the well's production casing from the oil reservoir. Having pressure-tested the plug, they began removing the drilling fluids from the well bore by pumping seawater into it.

Displacing the mud with relatively lighter seawater reduced the hydrostatic pressure inside the well, creating a negative pressure condition compared to reservoir pressures outside the well bore casing. This should not have been a problem, as the cement cap had been placed to "seal" the reservoir pressure from the well. However, the cement used to seal the reservoir from the well bore casing failed. This failure allowed large volumes of oil and gas under extreme pressure to travel up through the subsea well control equipment and the drilling riser to the deck of the *Deepwater Horizon,* where it encountered an undetermined ignition source.

The *Deepwater Horizon* oil drilling rig. U.S. Navy photo by Petty Officer 1st Class Michael B. Watkins.

Regulating MODUs on the Outer Continental Shelf

Several agencies of the federal government share regulatory responsibility and jurisdiction over activities in the U.S. Outer Continental Shelf (OCS). MODUs in the OCS are regulated by the Coast Guard, as well as two Department of the Interior agencies: the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE).

BOEM's primary responsibility is to manage the development of the United States's offshore resources, which include minerals, petroleum, natural gas, and renewable energy sources, like wind power. For MODUs operating on the OCS, BOEM regulates where they can drill and what can be exploited for commercial purposes through its management of oil and gas lease sales.[1]

BSEE is "responsible for developing, implementing, and enforcing regulations concerning oil, gas, and sulphur exploration, development, and production operations on the Outer Continental Shelf. BSEE also reviews and approves oil spill response plans submitted by owners and operators of offshore facilities and undertakes periodic inspections of oil spill response equipment."[2]

Because of overlapping jurisdiction within USCG and BSEE regulatory authorities, the two agencies have entered into a series of Memoranda of Agreement to "provide specific guidance on each agency's role and shared responsibilities for regulating various OCS activities, facilities and units."[3] These agreements clarify the roles and functions each agency will perform under their respective authorities in order to coordinate regulatory responsibilities effectively.

For its part, the USCG prescribes rules for the design, construction, equipment, inspection, and operation of MODUs. Different regulatory requirements apply to U.S. and foreign flag MODUs.[4] MODUs registered in the U.S. are treated much like any other major category of vessel regulated by the USCG. They have their own dedicated subchapter in Title 46 of the Code of Federal Regulations, must be issued a USCG Certificate of Inspection (COI) in order to operate, and have the option to enroll in the Alternate Compliance Program.

The Coast Guard regulates foreign-flagged MODUs operating on the OCS in the capacity of a "coastal state." Coast Guard regulations for foreign flag MODUs allow the option to comply with the standards applicable to U.S. flag MODUs, or the International Maritime Organization's "Code for the Construction and Equipment of Mobile Offshore Drilling Units," simply known as the MODU Code.

More than four decades ago, IMO—then known as the Inter-governmental Maritime Consultative Organization—recognized the need to establish standards for MODUs. They were increasingly moving and operating in and out of territorial waters of different countries, leading to the desire for consistent standards of safety and operational requirements among varying coastal state requirements. IMO decided that applying the requirements of the International Convention for the Safety of Life at Sea ("SOLAS") was inappropriate for MODUs, and developed the MODU Code to provide a standard for these units equivalent to the requirements of SOLAS. It was first adopted in 1979.[5] Revised versions of the MODU Code were adopted in 1989 and 2009.

Unlike the SOLAS convention, which was developed by the IMO, the MODU Code is considered a non-mandatory standard; thus, no member of the IMO, including the U.S., is obligated to impose its provisions. However, the U.S. accepts compliance with the MODU Code as an equivalent to USCG regulations, so long as the MODU complies with several additional specific requirements. Regardless of the

Proposed MODU Code Amendments

Areas of Recommended Improvement	Amendments Proposed
Sustain the integrity of areas classified as hazardous areas due to the possible presence of flammable vapors	• Qualified personnel are to perform repairs, overhauls, and maintenance in accordance with appropriate and recognized standards • To ensure certifications remain in force, maintain a record of service for all work performed on electrical equipment in hazardous zones • To mitigate the potential for ignition risk, require certification or other restrictions to control the use of portable equipment introduced into hazardous areas for periodic use
Enhance the design of passive systems to resist the effects of blast, heat, and flame characteristic of hydrocarbon fires	• Further limit the placement of accommodations, vital machinery, and equipment in spaces adjacent to the drill floor and other high-risk areas • Establish a new, more robust "H-60" fire boundary standard in place of the "A-60" fire boundary standard for the protection of crew in higher-risk industrial areas, and provide additional firefighting capability at the drill floor • Use recognized standards when performing explosion blast risk evaluations, where necessary
Positioning/ station-keeping of the MODU while connected to the seabed	• Clarify operational measures to sustain well integrity during operations • Clarify the authority of the person in charge (PIC) to enhance communication and control during critical and emergency operations • Where a master is assigned, ensure the master is designated as the PIC at all times
Focus on training, drills	• Refine the frequency and scope of emergency drills • Add training for davit-launched life rafts • Provide for alternative methods for lifeboat drills that complement conventional hands-on exercises

standard applied, in lieu of a COI, the Coast Guard issues a certificate of compliance to foreign-registered MODUs. *Deepwater Horizon* was one of these, holding a certificate of compliance on the OCS and certificated to the requirements of the Republic of the Marshall Islands, which mandates compliance with the IMO MODU Code.[6]

Amending the IMO MODU Code

In response to the *Deepwater Horizon* casualty, the United States, as the coastal state, and the Republic of the Marshall Islands, the flag state, launched investigations into the causes of this terrible accident. The Marshall Islands participated in public hearings held as part of the joint investigation conducted by the Department of the Interior, as well as the Department of Homeland Security. The reports and recommendations produced by these independent investigations were forwarded to the IMO for consideration toward possible improvements to its standards and instruments.

Subsequently, the United States, the Marshall Islands, and the International Association of Drilling Contractors[7] submitted a joint paper requesting that IMO's Maritime Safety Committee consider amending the 2009 MODU Code. The committee accepted the request and directed a subordinate subcommittee—ship systems and equipment—to review the MODU Code with the specific purpose of recommending amendments in support of safety and operational improvements.

The proposed MODU Code amendments were based on a review by the IMO's Subcommittee on Implementation of IMO Instruments of the coastal and flag state investigation reports and an initial proposal the U.S. submitted to the ship systems and equipment subcommittee. The IMO Maritime Safety Committee, at its 98th session on June 9, 2017, adopted resolution MSC.435(98) on "Amendments to the Code for the Construction and Equipment of Mobile Offshore Drilling Units, 2009 (2009 MODU Code)" for mobile offshore drilling units, the keels of which are laid or at a similar stage of construction on or after 1 January 2020.

MODU Code Amendments

The changes to the IMO MODU Code directly address many of the recommendations resulting from the *Deepwater Horizon* investigations, largely impacting fire protection, lifesaving and emergency procedures, and operations addressed in the code. Though many of these recommendations weren't created based on causal factors or conditions present in the casualty, through the intense scrutiny of the investigative process they were identified as elements that could be improved to possibly prevent or mitigate similar casualties in the future. The recommendations make incremental but important changes in the following areas:

- Sustaining the integrity of hazardous areas
- Enhancing the design of passive systems

- Positioning/station-keeping of the MODU while connected to the seabed
- Focus on training and drills

In the area of lifesaving, amendments include the need to design lifeboats that account for the larger-than-average personnel who may serve on MODUs as well as training in the use and deployment of davit-launched life rafts.

Of particular note is the carriage of a dedicated rescue boat—one that does not also serve as a lifeboat, a provision allowed in the current MODU Code and SOLAS. The *Deepwater Horizon* evacuation clearly highlighted the effectiveness of a dedicated rescue boat, deployed by the offshore support vessel (OSV) *Damon Bankston* attending the rig that day.

Deepwater Horizon had a lifeboat that was dual-certificated as a rescue boat, but all of the available lifeboats were used to transport the crew to safety. The rescue boat from the *Damon Bankston*, skillfully handled by its crew, successfully rescued several crew members who jumped from the burning MODU and then assisted the rescue of those who had escaped in the one life raft deployed.

These MODU Code amendments address facets of the prevention and mitigation of offshore incidents. Collaboration undertaken among industry and regulatory stakeholders in assessing the incident investigations and developing these amendments is indicative of the partnership necessary to address the perpetual list of highly complex and novel issues that pervade the offshore industry.

Mobile Offshore Drilling: Constantly Evolving

While the *Deepwater Horizon* tragedy sadly illustrates the dire consequences of a drilling accident, the incident provided a reminder that preventative measures and mitigation strategies must be continually assessed and, where possible, improved to reduce the risks associated with offshore drilling. Besides the MODU Code amendments put forth since the tragedy, the industry has made other enhancements in equipment design as well as to operational processes involving well control equipment, safety, management systems, personnel competence, and oil spill containment, resulting in substantial improvements to the safety of offshore operations.

According to the latest U.S. Energy Information Administration figures (2015), offshore oil production accounted for nearly 30 percent of total global crude oil production.[8] With most long-term forecasts predicting steady increases in the demand for hydrocarbon-based energy through 2050—notwithstanding anticipated growth in the generation of power from renewable sources—reliance on offshore sources of oil and gas, and the assets necessary to bring these resources to market, will certainly continue.

As production of each barrel of oil becomes increasingly more difficult and costly to achieve, continued innovation will be crucial to meeting the challenges of tapping even deeper reservoirs in areas of the world previously considered inaccessible. Production and drilling companies, vessel designers, equipment fabricators, and large-scale shipyards continue to collaborate on the evolution of a MODU fleet that will enable greater well bore total depth while operating in ever deeper water, and further offshore. Safety standards must evolve to keep pace with industry innovation.

International Association of Drilling Contractors

Additional details regarding a variety of oil and gas drilling topics, including offshore drilling, may be found on the International Association of Drilling Contractors' (IADC) website at www.iadc.org.

About the authors:

Mr. Jim Rocco joined the International Association of Drilling Contractors as Senior Director of Policy & Regulatory Affairs in 2015 after 23 years of Coast Guard active duty service in port operations and marine compliance, including several Washington, D.C., assignments. He earned his MBA from Northern Illinois University and a Masters of International Public Policy in energy resources from the Johns Hopkins School of Advanced International Studies.

After 21 years on active duty with the U.S. Coast Guard, Mr. Brian Bubar joined International Registries, Inc. He assists in technical marine matters for the Marshall Islands Registry and serves on their International Maritime Organization delegation. He is a marine engineering graduate of the Maine Maritime Academy and received a third engineer's license. He earned his Master of Engineering degree in electrical engineering from Clarkson University.

Mr. George Grills has worked in military and civilian assignments for the Coast Guard for more than 20 years. A 1994 graduate of the USCG Academy with a master's degree in mechanical engineering from the University of Massachusetts, Amherst, he is a licensed professional engineer working at Coast Guard headquarters.

Endnotes:

1. www.boem.gov/
2. www.bsee.gov/what-we-do/offshore-regulatory-programs/regulations-standards
3. Memorandum of Understanding between BSEE and USCG dated 27Nov12, found at www.uscg.mil/hq/cg5/cg522/cg5222/docs/mou/BSEE_USCG_MOU_NOV_2012.pdf
4. See 46 CFR Subchapter I-A (parts 107-109) for domestic MODU regulations, or 33 CFR Subchapter N, "Outer Continental Shelf Activities," for foreign flag MODUs.
5. IMCO Resolution A.414(XI), adopted 15 November 1979.
6. In 2002, the USCG compared the Republic of the Marshall Islands' MODU standards, MI-293, to the 1979 and 1989 MODU Codes and the U.S. requirements for existing MODUs. In a letter dated 9 August 2002, the USCG confirmed that the Republic of the Marshall Islands standards "provide a level of safety that is generally equivalent to the applicable international and us requirements to operate on the US OCS." Accordingly, the USCG accepts the Republic of the Marshall Islands' issued MODU safety certificates as evidence of compliance with the 1979 and 1989 MODU Codes and with USCG requirements for MODUs under 33 CFR section 143.207(c) and 33 C.F.R. section 146.205(c).
7. Since 1940, the International Association of Drilling Contractors has exclusively represented the worldwide oil and gas drilling industry, and the organization has been a recognized IMO-participating NGO delegation since 1975.
8. See "Offshore production nearly 30% of global crude oil output in 2015," www.eia.gov/todayinenergy/detail.php?id=28492#.

In the News: Hurricane Response 2017

Hurricane Harvey

Texas—August 25

Petty Officer Ryan Hicks, assigned to Coast Guard Maritime Safety and Security Team New Orleans, rescues a child in support of Hurricane Harvey relief efforts in Port Arthur, Texas, on August 30, 2017. The Coast Guard partners with local emergency operation centers and the established incident command post to manage search and rescue operations. U.S. Coast Guard photo courtesy of Maritime Safety and Security Team New Orleans/Released

Regulating New Materials

Fire protection implications and concerns

by LT Charles Taylor
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The marine industry is under pressure to reduce emissions while maintaining its competitiveness with other forms of transportation, leading it to seek new ship construction materials. Advanced materials may enable the construction of more efficient ships by reducing weight, corrosion, fatigue, and costs. Conversely, new materials may also involve risks due to uncertainties in the materials' properties and performance, as well as potential inadequacy of current regulations and standards. This inadequacy may be due to regulations and standards having been developed for other materials or not anticipating new hazards created by new materials.

There have been many instances when a material, thought to be truly remarkable when introduced, turned out to be unintentionally problematic. For example, asbestos—an outstanding noncombustible insulator—was widely used until its hazardous health effects became known. Polychlorinated biphenyls (PCBs) work well in transformers, but have a very long life in the environment and adversely impact human health. Halon is an incredible fire extinguishing agent—barring its significant ability to deplete the ozone layer. These are just a few examples where the test of time upended the "ignorance is bliss" rule.

We don't yet know what new material on the horizon may revolutionize ship building next. To provide an example, let's imagine it's nanotechnology—carbon nanotubes and other materials designed at the molecular level. Consequently, there could be a drastic drop in the price of existing high-cost engineering materials, or old materials may be reconsidered due to environmental concerns and changes in processing methodologies. While much is unknown about the direction and future of ship building, what we do know is that ship safety regulations and standards must also evolve as ship-building techniques change.

Hindsight Is 20/20

By nature, regulations are backward looking and unfortunately, all too often, tombstones serve as the highway markers of regulatory development. New U.S. Coast Guard regulations must show a benefit to society that exceeds the cost to industry based on casualty data for the past 10 years, per Executive Orders 12866 and 13563.[1]

Concerns are usually considered theoretical until an incident or casualty proves them valid. A casualty often creates political pressure to develop or improve existing regulations. Typically, the larger the casualty, the greater the societal concern and, by extension, commensurate political interest. *Exxon Valdez* and *Deepwater Horizon* serve as prime examples. While new regulations are intended to address the cause of the latest casualty in order to prevent future occurrences, they often enshrine the materials and technology of the time.

Regulatory Blind Spots

Industry standards also reflect the current state of materials and technology. These consensus standards are created by industries and other stakeholders to ensure reliability, compatibility, safety, and a host of other aspects that must be considered for a particular market. As such, they are not necessarily driven by casualties and not required to meet a rigorous cost-to-benefit requirement. These standards can freely address known issues and concerns, but are unlikely to address issues that those developing the standards have yet to solve.

It wasn't that long ago that all ships were constructed of wood. In order to avoid shipboard fires, a crew depended on good housekeeping and similar practices preventing ignition. Additionally, despite the clear advantages of larger vessel design, the material properties of wood limited ship size. When technology allowed a shift from wooden to steel hulls, a new era of ship design dawned transforming the maritime industry, as the construction of larger vessels with much greater passenger and cargo capacity could finally be realized.

The shift from wood to steel was not 100 percent in the early adoption of steel hull construction, as vessel superstructures and interiors still incorporated a considerable amount of wood. This practice likely stemmed from tradition, aesthetics, and possibly even some feelings of nostalgia. Unfortunately, this wood-to-steel ratio would ultimately result in tragedies time and time again.[2]

The fire aboard the SS *Morro Castle* in the late summer of 1934 is a stark reminder of this type of hybrid's vulnerabilities. The vessel was en route from Havana to New York City when a fire broke out in the first class lounge. The wooden facades and finishes fed the fire, allowing it to rapidly spread throughout the interior. As with most casualties, a cascade of failures contributed to this disaster, but the extensive use of combustible materials was the primary driver for this catastrophe, resulting in 137 deaths.

Star Princess

For passenger ships, the emphasis on fire prevention has historically focused on the interior of the ship. There was less concern regarding the deck because there were no large quantities of cargo there to burn. Even the furnishings on promenades were restricted to deck furniture. Conventional wisdom held that fire mostly originated and spread in the interior, and that any fire reaching the exterior would become an issue only if it blocked escape routes. Thus, the severity of the balcony fire on the *Star Princess* was shocking.[3]

The ignition source was believed to be a cigarette discarded from above that landed on a cabin balcony, something that was considered a nuisance—not a major threat. Nonetheless, a fire started on that balcony and spread quickly by jumping up and aft from balcony to balcony on the port side. While the fire did spread into many staterooms through shattered sliding glass doors, it did not extend further into the ship, except for smoke.

The investigation determined that the addition of plastic partitions was a primary factor in the progression of the fire along the outside of the vessel's superstructure. These materials were installed as a lightweight, corrosion-resistant

The *Star Princess* after the portside fire. Image courtesy of UK Marine Accident Investigation Branch.

(Left) A *Star Princess* balcony before the fire. (Right) A corridor after the fire. (Below) The melted aluminium structure. Images courtesy of UK Marine Accident Investigation Branch.

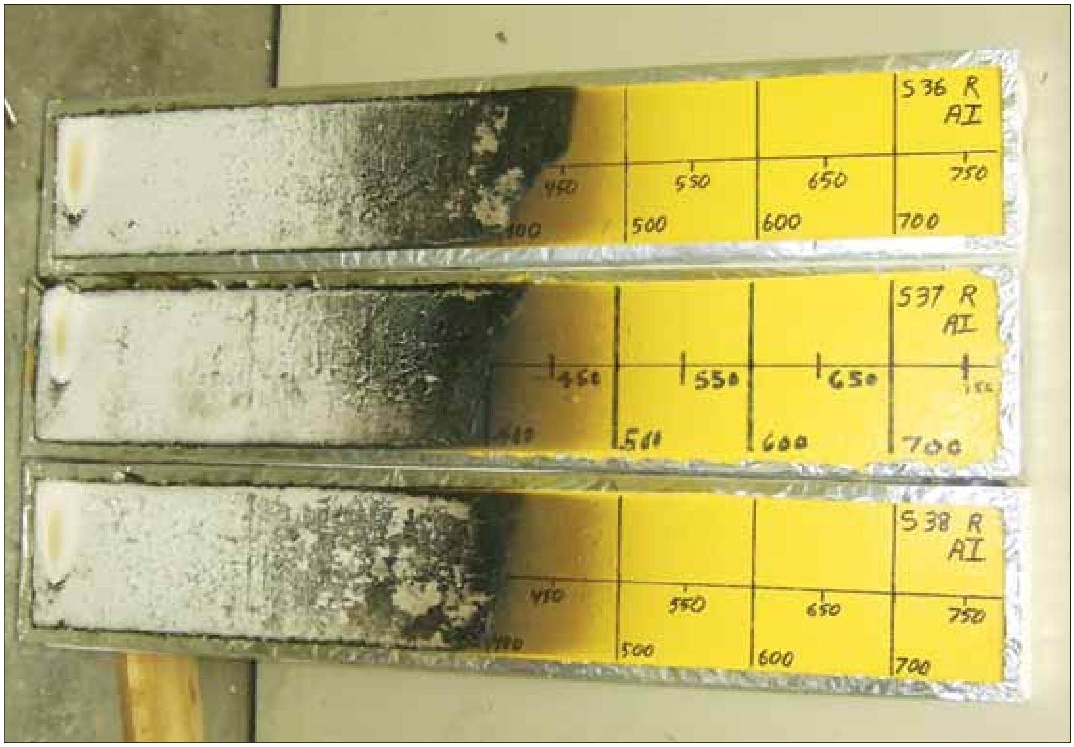
privacy barrier between cabin balconies, but their ability to rapidly spread fire had not been thoroughly considered. In relatively short order, the International Maritime Organization (IMO) amended the International Convention for the Safety of Life at Sea (SOLAS) to address the lack of fire protection for cabin balconies (SOLAS II-2/7.10).

Regulatory Use of Independent Standards

Regulations may specify third-party fire standards for certain materials used in building and outfitting ships. Compliance is checked at three points during construction: type approval, plan review, and field inspection.

Type approval verifies that a material or equipment has met the requirements, which may include independent third-party standards, for an applicable approval category; and is conducted independent of any ship construction. At its core, type approval is a labor-saving program in which manufacturers do not have to qualify their products for each vessel. Instead, the shipbuilder can select from an approved list of materials and equipment without getting into the standards, and the plan reviewers can direct their attention to where and how the materials are being used on a particular vessel.

The downside of this approach is that it does not lead to performance-based engineering. The upside is that replacing one approved item with another does not require a detailed engineering analysis potentially involving hundreds of computer model simulations. This makes



Specimens of paint after being tested to Part 5 of the 2010 FTP Code. The numbers indicate the distance from the left edge in centimeters. Extension of the flame is only measured along the centerline. U.S. Coast Guard photo by Mr. Louis Nash.

replacing approved items, such as a chair, much easier and at a lower cost.

Weakness of Using Third-Party Standards

Most of the fire test standards for materials used in shipbuilding are found in the International Code for Application of Fire Test Procedures (FTP Code).[4] This code was developed by the IMO over many years in an effort to harmonize requirements and provide guidance to flag administrations with limited resources.

For most administrations, the goal was to avoid disrupting their industries. Based on the testing of materials that we had already accepted and those we would not accept, the U.S. Coast Guard proposed acceptance criteria for a significant number of these test procedures—the point being that those criteria were based on the materials in use at that time. The first version of the FTP Code was adopted in 1996 after almost two decades of development.

These standards are screening tests to support a yes or no decision for type approval. Without the need to produce engineering data, changes in testing standards are typically evaluated for their effect in disrupting the market, increasing the reproducibility of a particular test, and making the testing easier for the laboratory. That said, however, we lack the ability to quantify what effect a change in the testing standards would have on an actual fire.

Non-Combustibility Test

One of the main fire test standards in the FTP Code is the non-combustibility test.[5] This test ensures that a material will not contribute to a fire, thus limiting its severity and duration. For the test, a specimen is shaped into a cylinder and lowered into a tube furnace with a temperature of 750°C, or 1,382°F. The subsequent amount of flaming, weight loss, and temperature rise are measured and must remain within defined limits in order for the material to pass the test.

The forerunner of the test procedure was incorporated into the Code of Federal Regulations in 1976. It was introduced and adopted by IMO and became the International Organization for Standardization (ISO) standard 1182.

The ISO technical committee changed the test procedure—from the temperature rise and 20-minute duration to the drop from maximum temperature, to the steady-state temperature without a set limit on test duration. The IMO adopted the procedure as modified by ISO and adopted revised criteria based on comparative testing. However, the long test duration of several hours was unpopular. The IMO subsequently set the duration at 30 minutes. This was considered adequate for the materials in use, like mineral wool, fiberglass insulation, and calcium silicate boards.

The regulatory benchmark for a standard fire is represented by what's known as the standard time-temperature curve. In this standard curve, a 750°C threshold is reached within the first 17 minutes, continuing on to 841°C at 30 minutes, and to 945°C at 60 minutes. While exposure to 750°C sounds hot, it is actually on the lower end of the temperature range for a fully-involved shipboard fire. It is, in fact, possible for a new material to pass the non-combustibility test, but become exothermic—releasing heat—at higher temperatures.

In July 2005, the U.S. Coast Guard was asked about approval testing for a product that was being developed under a small business innovative research contract issued by a federal agency. We were told this product, a coal-based foam, was being developed for use as a non-combustible insulation of the type used within fire boundaries. We were skeptical that a coal-based anything would be considered non-combustible. Although test reports were never submitted, we were told the foam passed the non-combustibility test but failed the fire-resistance test.[6] This suggests that the non-combustibility test has an inherent shortfall and will successfully pass materials that are slow-burning and have very limited flaming. This advanced material was never accepted for use in ship building.

Flame Spread Test

The spread of flame, such as down a corridor, is controlled by the test for surface flammability.[7] In this test, a 155 mm, or 6 inches, tall by 800 mm, or about 2.5 feet, long test specimen is exposed to a radiant heat panel in a vertical orientation. The panel is angled slightly away from the test specimen, such that the radiant heat flux varies along the length of the specimen (so it is less intense farther from the starting point). There is a requirement that the spread of flame is measured only on the horizontal centerline of the specimen. This restriction increases reproducibility of the test by avoiding edge effects. It also avoids the variation in radiant flux over the height of the test specimen.

The Coast Guard has noted that this test method does a poor job of handling veneers mounted on honeycomb panels. This type of panel consists of a honey-comb core sandwiched between two thin sheets of veneer. The core and sheets are fabricated from aluminum due to the non-combustibility requirement.

According to the test, the adhesive used to glue the sheets to the core is typically qualified as a low-flame spread product. When a veneer mounted to a panel is tested, the adhesive melts and collects at the bottom of the test specimen, sometimes burning in the process—but it is not on the centerline. In the real world, that panel may be 2,400 mm (or 8 feet) tall instead of 155 mm, resulting in much more adhesive that could collect at the bottom of the panel during a fire. However, we are not aware of any casualty data showing that this is a problem.

Smoke and Toxicity Test

The production of smoke and toxicity is controlled by the smoke and toxicity test.[8] In this test, a small sample—75 mm by 75 mm (3 inches by 3 inches)—is placed horizontally under a conical heater within a test chamber. Visibility is measured within the chamber, and smoke samples are taken to measure the concentration of seven toxic gases.

Each concentration is evaluated separately against the acceptance criteria for that gas. For example, a material that produces only one toxic gas, but exceeds its allowable limit, fails. By contrast, a material that produces all seven gases, each just below their acceptance criterion, passes. There is

In this flame spread test, the specimen is tested for surface flammability (Part 5 of the IMO 2010 FTP Code). The flame is driven by the radiant panel on the left, which has been mounted at an angle to the specimen. U.S. Coast Guard photo by Mr. Louis Nash.

no check for a material that produces a toxic gas that is not one of the listed gases.

There are two ways for a material to be exempted from the smoke and toxicity tests. The first is by passing the non-combustibility test discussed above. The second is a regulatory trade-off made to encourage the use of materials with very low flame spread. This trade-off assumes a material that is difficult to ignite and slow to spread a fire will not involve much material in the early stages of a fire. As such, it will produce less smoke and toxic gas.

In practice, some of the approved materials qualifying as "very low flame spread" cannot pass the smoke and toxicity test. These products achieve a very low flame spread due to high concentrations of chlorine, bromine, and other fire retardants, which can produce significantly irritating and harmful gases.

Regulatory Voids

Regulations are in place to address known problem areas in the current state of technology and practices. For example, the issue of structural collapse for ships in fires is covered in regulation 11 of Chapter II-2 of SOLAS, which requires steel construction for vessel hulls, superstructures, and other primary structural components such as bulkheads and decks. Welded steel ship construction will almost never collapse in a fire, regardless of the fire's duration.

Regulation 11 also permits aluminum construction if insulated to pass one hour of the standard fire test.[9] This provides one hour of protection against structural collapse for aluminum ships. The adequacy of this protection for a large ship is untested. It may provide insufficient time for abandoning a cruise liner, and may be at odds with the relatively new return to port requirements for large passenger ships.[10]

Due to the significant expense of building a large ship from aluminum, the issue of structural collapse has not been thoroughly evaluated. The expected duration of the fire is not explicitly addressed in the regulations; instead, the regulations specify a non-combustible structure and containment. It is assumed the fire-rated divisions augmented by the crew cooling the boundaries will contain the fire until the fire burns out. Any new structural materials that react or ablate at high temperatures could negate this assumption.

Summary

Safely incorporating new materials in ship construction presents a challenge to proponents, regulators, and engineers. As outlined above, novel materials often come with many unintended side effects, so their proponents should understand that these second- or third-order issues may negatively impact vessel safety, stability, etc., in addition to having serious economic repercussions due to recalls, retrofitting, etc. Regulators will have to weigh whether current regulations or standards are outdated and hinder advances in ship-building, or whether they still function as intended to prevent casualties. Engineers working in both design and regulations will have to be aware of the potential pitfalls on both sides of the issue.

Major ship fires are infrequent, so 10 to 20 years may pass after a relatively small change in material design is involved with, or directly cause, a significant fire. Depending on the degree to which the material change has been incorporated by industry during that intervening time, the cost of correction may be quite high.

It is vital that all interested parties maintain an awareness of past casualties and conduct thorough engineering analyses in order to enable the safe introduction of new materials and designs. If done well, we can avoid many past mistakes. If done poorly, we will have new tombstones to serve as regulatory guideposts when adopting the materials of the future.

About the authors:

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Advancements in Search and Rescue

Technological evolution in a digital SAR regime

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Search and rescue (SAR) is one of the Coast Guard's oldest, largest missions. From 2010 to 2015, the USCG conducted more than 114,000 SAR cases, saving more than 22,000 lives.[1] To keep up with this continually changing mission, the Coast Guard is constantly trying to leverage new SAR technologies to help mariners in distress and prevent loss of life, injury, and property damages. Judging by past performance, we expect to continue to advance SAR effectiveness thanks to such technology.

Alerting and locating are two key components of search and rescue technologies The alerting function informs people that the mariner/vessel is in distress, while the locating function informs the rescuers of the location of the mariner/vessel. The best SAR devices will include both of these functionalities, but the ultimate goal of SAR technologies is to take the "search" out of "search and rescue."

Historical Search and Rescue

Historically, when mariners were in distress, they would wave flags or shoot off flares to notify people in the vicinity. While these technologies are useful, they are quite limited in terms of their effective distance and ability to alert rescuers that help is needed.

In the early 1900s, shipboard radios became more common, allowing distress signals to broadcast farther than ever before. Although this technology increased the effective distance of alerting, it did not significantly improve the locating functions of the device. Basic direction finding (DF) bearings on a radio transmission could be taken, but bearings from two or more DF sites were required to obtain an estimated position of the ship in distress.

A Coast Guard Station New York 45-foot Response Boat-Medium picks up speed in the waters near Staten Island. U.S. Coast Guard photo by Petty Officer Steve Strohmaier.

Current Devices

Many historical SAR devices have been upgraded over the last decade, and several new devices have dramatically changed the way the Coast Guard responds to mariners in distress. These changes have come at a time when electronics and digital devices are becoming more prevalent in our daily lives. Correspondingly, these technological improvements have increased the effective distance of the alerting functions while improving the locating capability and precision of the devices.

Rescue 21 System—The National Distress and Response System coastal sites have recently been upgraded to the Rescue 21 system,[2] which has increased the effective alerting distance to 20 nautical miles and added improved direction finding capabilities. This system is currently available

Once activated, a properly registered emergency position-indicating radio beacon (EPIRB) will transmit an electronic signal to notify the Coast Guard of the distress situation and its location. U.S. Coast Guard photo by Petty Officer Robert Brazzell.

throughout most of the United States and is expected to be completed in 2017.

Rescue 21 allows the Coast Guard to determine the direction of a distress call, receive GPS coordinates from a VHF digital selective calling (DSC) radio, and also use multiple frequencies at the same time. With all of these benefits, the Coast Guard will be able to respond to mariners in distress faster and more effectively.

Distress Beacons—Emergency position-indicating radio beacons (EPIRBs), personal locating beacons, and the aeronautical emergency locator transmitter are 406 MHz distress beacons which have a dedicated satellite system, the Cospas-Sarsat (Search and Rescue Satellite Aided Tracking) System, for detecting these distress alerts. Upon detection, the distress alert is distributed to the appropriate rescue coordination center, leading to smaller search areas and faster rescues. EPIRBs alone have helped save more than 22,000 people worldwide since Cospas-Sarsat became operational in the 1980s.[3]

Cell Phones—These are often used as another alerting device. Though their range is limited, and they're not typically waterproof, cell phones can be useful in certain situations. For example, recreational boaters within range of cell phone towers may be able to call the Coast Guard or 9-1-1 when in distress.[4]

As recommended, the best practice is to use a cell phone as a back-up to a marine DSC radio. When using a marine DSC radio, a mariner not only talks to the Coast Guard, but also other mariners in the vicinity who might overhear the broadcast and be able to render assistance. The other advantage of using a marine DSC radio is its direction-finding capability, which a cell phone lacks.

The popularity of the devices described above, and other types of GPS devices has led to commercial companies offering a commercial locating, tracking, and emergency notification service. For a fee, these companies will provide the service, and they should also have arrangements with the appropriate SAR authority. This service is not part of the international SAR system, which has dedicated frequencies for distress alerting.

Game-Changing New Devices

New SAR devices and technologies that often incorporate the functionality of several current devices in a single piece of equipment are still being developed, and are becoming more user-friendly. When a mariner is in distress, they will most likely choose the SAR device that is the easiest to use. Here are a few examples of some relatively new devices or prototypes under development:

AIS-SART—AIS-SART is a new device that combines an Automatic Identification System with a Search and Rescue Transmitter.[5] This device is portable and can transmit a text message, followed by a position message, eight times

A personal emergency position-indicating radio beacon (EPIRB) can be attached to an individual, allowing the Coast Guard to identify and track the individual in a distress situation. U.S. Coast Guard photo by Petty Officer Barbara L. Patton.

a minute. During testing, it has been shown to have "good potential as a life-saving device." [6] Though AIS technology was developed originally for vessel collision avoidance, the addition of an AIS onto the SART is intended to assist in locating survival craft like lifeboats and life rafts. This helps overcome the problem of rapid identification of multiple radar targets, such as survival craft among ice floes or floating debris. This enables aircraft to rapidly search large areas while opening the door for satellite detection.

Maritime Survivor Locating Devices—Maritime survivor locating devices, signaling devices designed to alert rescue personnel in the local vicinity that someone is in distress, can result in a rapid response. Because these devices do not need a large power supply to transmit over a long distance or time, they are small enough for users to wear on their clothes or lifejacket.[7]

Digital Selective Calling—Digital selective calling is a standard for sending pre-defined digital messages via the medium-frequency, high-frequency, and very-high-frequency maritime radio systems. It is a core part of the Global Maritime Distress Safety System.

Electronic Visual Distress Signal Devices—Electronic visual distress signal devices (eVDSDs) are reimagining traditional flares for use in the digital world. Proposed eVDSD designs are made with LED lights that last longer than a flare. The Coast Guard is currently working with various agencies to develop a standard for eVDSDs.[8]

Meosar—A Medium-altitude Earth Orbit Search and Rescue system is currently in development. This system will interface with the current low-altitude and high-altitude systems to form a single notification system that will streamline distress alerting for the international maritime community.[9]

In 2015, the Coast Guard launched a free boating safety mobile app that can be used throughout the U.S. It was not designed to replace a boater's marine VHF radio, but rather to provide an additional boating safety resource. This app is equipped with a button to call the nearest Coast Guard command center. U.S. Coast Guard graphic.

Conclusion

As technology continues to advance, we should expect more improvements in devices with increased range, multiple functionality, and compact size. Fortunately for those using our waterways, these new devices are helping to increase the number of lives saved during emergency situations.

About the author:

LT Laura Fitzpatrick has served in the U.S. Coast Guard for nine years and is designated as a marine safety, security, and stewardship professional. She has served as a marine inspector and investigator, was awarded a Master of Science degree in mechanical engineering by the University of Hawaii, and is currently working as a staff engineer in the Lifesaving and Fire Safety Division (CG-ENG-4) at U.S. Coast Guard headquarters.

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Testing our Defenses Against Aquatic Nuisance Species

Developing a means to rigorously assess treatment technologies for ships

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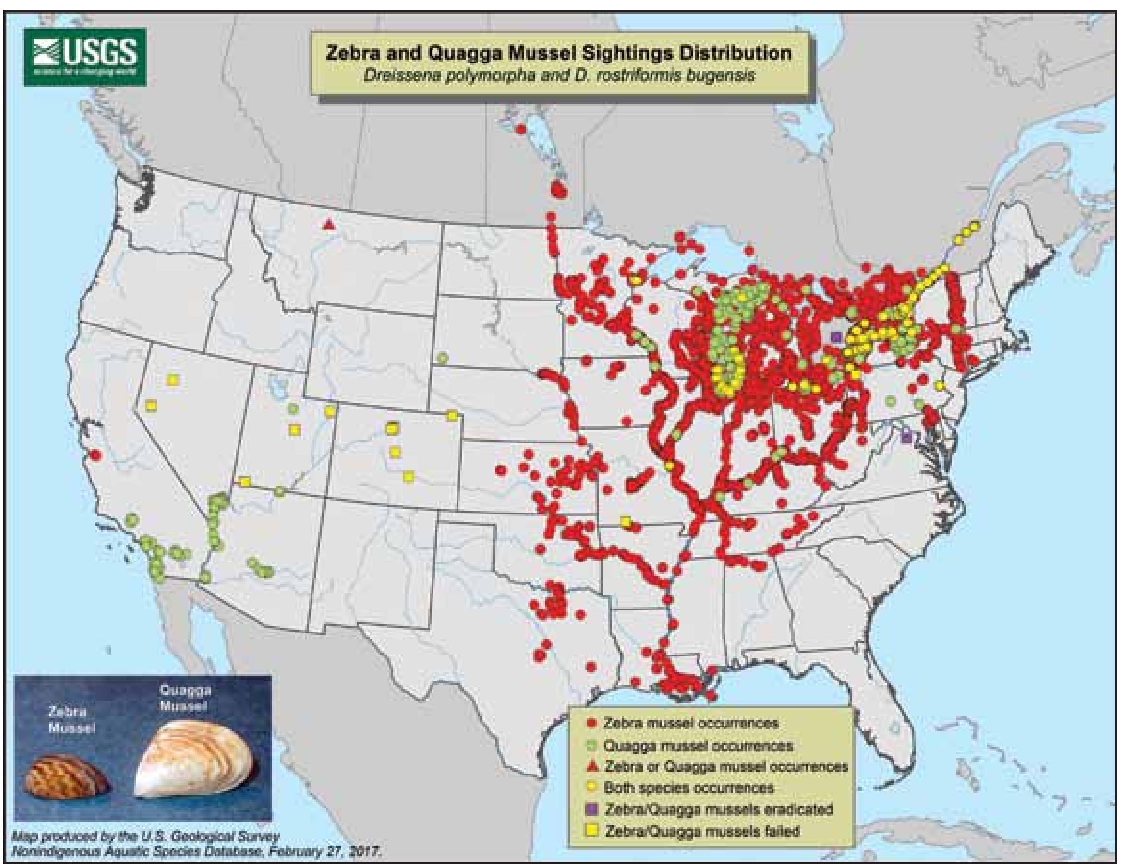
The 1970s and 1980s saw a rise in global awareness of the threats posed by invasive species, specifically the potential negative effects of organisms discharged in ships' ballast water. Animals, plants, and microorganisms translocated by ships have caused large-scale invasions resulting in great ecological and economic harm.

The zebra mussel, a well-known aquatic, ship-borne invasive species, is one of the earliest large-scale invasions documented in the United States. This thumbnail-sized mollusk arrived in North America from Eastern Europe. Since its initial discovery in 1988 in Lake St. Clair, Canada,[1] its range and density have increased in a breathtaking manner.



Distribution map of the Zebra mussel *(Dreissena polymorpha)* and another invasive mollusk, the Quagga mussel, thought to have been transported to the Great Lakes in ships' ballast water. Map courtesy of Amy Benson, U.S. Geological Survey.

The zebra mussel is now found in all of the Great Lakes, throughout the Mississippi river drainage system, and as far west as California.

Zebra mussels now carpet some areas of the Great Lakes, with densities recorded as high as 700,000 per square meter.[2] Not surprisingly, zebra mussels have changed food web dynamics in overrun areas and have caused extensive economic damage by clogging water intake pipes and fouling underwater infrastructure.

Petty Officer Travis Kelly, Marine Safety Detachment Massena peers at a sample of ballast water from the motor vessel Eider through a refractometer in Montreal. The U.S. Coast Guard inspects all vessels' ballast water before they enter the Great Lakes. U.S. Coast Guard photo by Petty Officer William B. Mitchell.

Early invasions like the zebra mussels prompted the U.S. Congress to pass laws requiring the development of new ballast water management regulations. These regulations have included new water quality standards for discharged ballast water and new shipping industry approaches to treatment and compliance. This article will focus primarily on the protocols developed to test shipboard ballast water treatment systems for compliance with U.S. requirements.

U.S. and International Policy on Invasive Species

In response to invasions in U.S. waters, Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) in 1990. In 1996, Congress re-issued and amended NANPCA as the National Invasive Species Act. More recently, in 2012, the United States Coast Guard published regulations establishing a "discharge standard" to limit the number of living organisms released in ballast water.

Numeric limits for discharge standards are determined by the organism size class. As such, the allowable density of living organisms is quite low, reducing the likelihood organisms will colonize new waters. For organisms equal to or greater than 50 microns in size (typically zooplankton), the standard allows no more than 10 living organisms to be discharged per cubic meter of ballast water. For comparison, in Chesapeake Bay, small crustaceans called copepods, which tend to dominate that size class, are commonly found at densities ranging from 1,000 to 5,000 per cubic meter, with occasional instances of 20,000 per cubic meter.[3]

Image of a copepod approximately 1.5 mm (1,500 μm) long; these tiny crustaceans are commonly found in coastal waters. Photo courtesy of Lisa Drake, U.S. Naval Research Laboratory.

Working through the United Nation's International Maritime Organization (IMO), the international community has adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediment, 2004 (Ballast Water Management Convention), which entered into force on September 8, 2017. The Convention stipulates the same numeric discharge standards for each size class as the U.S. regulations.

Ballast Water Management Systems

In response to U.S. regulations and international expected requirements, a new industry for ballast water treatment has emerged over the past two decades. Most treatment approaches are borrowed from the water-treatment industry. Many are essentially miniaturized and marinized land-based methodologies, combined and designed to operate as a "ballast water management system" (BWMS). These systems typically combine a filtration step and a disinfection process such as chlorination or ultraviolet radiation. Operating a water treatment plant onboard a ship is complicated by the challenges of relatively little space and little time to accomplish the task.

Cost adds another challenge. An estimated 60,000 commercial vessels must comply with the U.S. domestic and the international discharge standard.

With an estimated expense of $1 million to install a BWMS on an existing ship, some vessels may be scrapped ahead of schedule to avoid the costly process of retrofitting a treatment system. Even so, the value of the BWMS industry has a staggering projected value of $30 billion to $50 billion USD.[4]

Testing Ballast Water Management Systems

To ensure that the newly developed treatment systems are effective, they must be tested with standard protocols so results can be compared between and among the various BWMS technologies. Such rigorous testing should demonstrate through widely available test results that the BWMS functions as intended across a range of operating conditions. To that end, in 2001, the USCG and the U.S. Environmental Protection Agency (EPA) signed a memorandum of understanding to develop a BWMS testing protocol under the umbrella of the EPA Environmental Technology Verification (ETV) program. Though the ETV program has since concluded, its aim was to speed environmentally friendly technologies to market through independent, third-party verification testing and provide "objective, high-quality, peer-reviewed performance data."[5]

To develop the ballast water testing protocol, a series of meetings and workshops was convened among the stakeholders, including BWMS vendors, shipping representatives, academicians, ballast water researchers, and regulators. As a result of the discussions and recommendations from the meetings, verification testing includes three types of tests: land-based testing, operation and maintenance testing, and shipboard testing.

The foundation of verification testing is the underlying quality management system. Tests must be conducted in a rigorous, repeatable, and standardized manner. Procedures must adhere to previously established quality assurance and quality control measures as outlined in a quality management plan (QMP) and quality assurance project plan. BWMS testing adheres to the quality assurance project plan drafted specifically for the BWMS being evaluated, and testing follows the policies and guidelines established in the test facility's QMP. All testing is overseen by a verification organization that is independent of the BWMS manufacturer. The verification process consists of planning and conducting the tests to verify the BWMS performance against the manufacturer's performance claims, as well as assessing and reporting the results.

From the discussions held among stakeholders and expert technical panels—and using relevant, available data—the draft Generic Protocol for the Verification of Ballast Water Treatment Technology (ETV Protocol) was produced for land-based verification testing.[6] The land-based protocol was drafted first, with the understanding that a shipboard protocol would follow. Accordingly, the shipboard protocol, which is being finalized, is expected to incorporate many of the methods developed for the land-based testing regime.

Determining the efficacy of a BWMS is a complicated process for both land-based and shipboard testing. It requires evaluating both engineering and biological parameters. Regarding the engineering aspects, the land-based test facility must replicate shipboard conditions, such as flow rates and pressure, and it must be able to collect water samples in a way that does not unintentionally kill organisms. Regarding the biological aspects, samples must be analyzed for organisms relatively quickly after collection to determine if they are living or dead. Delays in analysis potentially underestimate organisms that were living when the sample was collected but died before they could be counted. Given the complex nature of the treatment systems, the need to evaluate multiple system attributes, and the logistical hurdles involved in sample collection and analysis, the ETV Protocol for BWMS testing is, by far, the most complicated protocol developed under the ETV Program.

Because the draft ETV Protocol was based on theoretical scenarios, it needed to be evaluated to determine its veracity and applicability to BWMS verification testing. Subsequently, a pilot test was conducted at the full-scale ballast water treatment test facility at the U.S. Naval Research Laboratory in Key West, Florida. These full-scale tests were conducted from October 2006 through February 2007, using a commercially available BWMS, which performed well.

Testing the Effectiveness of BWMS

Land-based testing assesses the biological efficacy of a BWMS, or its ability to remove or kill organisms. Testing is conducted at a scale similar to that onboard a ship, using tanks capable of containing volumes of at least 200 cubic meters with pumps capable of producing flow rates of at least 200 cubic meters per hour. Land-based testing allows conditions to be relatively tightly controlled. For example, the concentration of sediment or living organisms in the intake water can be augmented to provide a challenging environment typically encountered by ships.

Operation and maintenance testing assesses the BWMS's engineering performance, not the biological efficacy.

Shipboard testing assesses the biological efficacy under less-controlled conditions than in land-based testing, to better reflect the circumstances of a shipboard environment.

As with all new processes, changes were needed to the draft ETV Protocol, and additional research was conducted to address testing challenges that arose during the pilot test. For example, the initial sampling guidance was amended,[7] and a new method was developed to determine if organisms were living.[8] In 2010, following the concurrence of the ETV Technical Panel and with additional reviews, the land-based protocol was finalized.[9] The ETV Protocol is now used to test BWMAs at USCG-certified independent laboratories around the world, and it is recognized as the standard for ballast water testing.

U.S. Naval Research Laboratory. Photo courtesy of Robert Brown, Azimuth Technical Consultants Inc.

Summary

In response to the early introduction of nonnative invasive species, national and legislative actions resulted in regulations limiting the discharge of living organisms in ballast water. As a result of these regulations, an industry has emerged to treat ballast water on ships, typically with new configurations and innovative applications of existing water treatment technologies. The rigorous protocol needed to test these BWMS was developed in cooperation with the USCG, EPA, and stakeholders. The overarching philosophy of the ETV Protocol—to provide a framework that allows BWMS to be tested in a rigorous, comparable manner—is a game changer for the ballast water treatment industry.

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Please note this work does not reflect the official policy of the U.S. Coast Guard or the U.S. Navy.

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In the News: Hurricane Response 2017

Hurricane Irma
USVI , Florida—September 10

Coast Guard crew members with the Florida Keys branch of the Emergency Support Function 10 Florida place an assessment sticker on the hull of a vessel displaced by Hurricane Irma in Boot Key Harbor, near Marathon, Florida, September 29, 2017. U.S. Coast Guard photo by Petty Officer David Weydert.

Integrated Shipboard Electric Power Systems

How the lithium-ion battery changed propulsion

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While the maritime industry can sometimes be considered staid and slow to incorporate cutting-edge technology, the opposite has often been true. The industry has moved from sail to paddle wheel, coal to diesel fuel, and wood hulls to steel in quick transitions over the last 200 years. The U.S. Coast Guard continues to see this pattern today, as submissions for novel designs of all types continue to grow.

The USCG Marine Safety Center receives submissions from across the country for lithium-ion battery hybrid vessels, 100 percent-battery-powered vessels, hydrogen-as-fuel vessels, and liquefied natural gas (LNG)-as-fuel vessels. All of these technologies are game changers.

The Path to Electric Propulsion Systems

Established in 1871, the Steamboat Inspection Service was formed in response to the increased safety hazards posed by steam propulsion—a game changer in its time. Just nine years later, the SS *Columbia* became the first vessel to install Thomas Edison's newly invented light bulbs and an electric auxiliary power system, laying the foundation for the invention of electric propulsion systems.

Electrical engineering and naval architecture advancements throughout the last century enabled the continuous development of electric propulsion, which ultimately resulted in modern integrated power systems. These systems are electric power plants simultaneously serving both the ship service loads as well as the propulsion loads.

While electric propulsion systems have always been popular in specific segments of the United States maritime industry, technological advancements in the 1980s significantly increased their viability. Now, integrated power systems that incorporate lithium-ion batteries are changing the game again, since the systems can now serve diverse ship needs and mission sets. The current regulatory framework did not envision this technology, however, so there are many unique challenges to overcome.

Evolution and Advancements

Numerous technological breakthroughs have influenced the evolution and desirability of electric propulsion aboard ships. The invention of the DC electric power system, AC electric power system, and advancements in power electronics—electronic devices used for transforming and converting electrical energy—all led to the increased feasibility and desirability of electric propulsion on ships.

The San Francisco-based *Alcatraz Cruise*, the nation's first hybrid ferry, is an eco-friendly vessel powered by solar panels, wind turbines, and grid electricity.
Photo by Supannee_Hickman / Shutterstock.com.

Current advancements in energy storage systems, like the lithium-ion battery, are fueling the desire to build vessels with modern integrated power systems—configurations

The Gees Bend ferry, operated by the Alabama Department of Transportation and Horn Blower Marine Services, is currently being converted into the first inspected, U.S.-flagged, all-electric, lithium-ion battery powered vessel. Photo courtesy of the Alabama Department of Transportation.

consisting of an energy storage system and a reduced number of internal combustion engines serving as prime movers. Vessels of such a configuration are more commonly known as "hybrid electric" or "all-electric" vessels.

The increased efficiency in energy conversion and increased electronic control has brought us to the current state of technology in shipboard propulsion and power plants. In 2008, *Hornblower Hybrid* became the first hybrid electric vessel with an integrated power system consisting of wind turbines, solar arrays, lead acid batteries, and a diesel engine, marking a significant milestone in U.S. maritime history. By 2014, the *Spirit of the Sound,* a small passenger vessel, received the first certificate of inspection in the U.S. for a vessel using lithium-ion batteries.

The United States doesn't have an all-electric vessel powered by lithium-ion batteries yet. Thus far, Norway has led the way in this category with the aptly named MF *Ampere*—the world's first fully electric battery-powered passenger and car ferry. The idea of building an all-electric commercial vessel in the U.S. is gaining popularity, though, and several projects are underway, including the retrofit and repower of the *Gees Bend* ferry operating in Camden, Alabama.

Thus far, Norway leads the way in all-electric vessels powered by lithium-ion batteries with the aptly named MF *Ampere.*

Current projects indicate a trend toward continuous development of the integrated electric power system, including developments that are likely to result in innovative uses of energy storage systems such as fuel cells, super capacitors, fly wheels, and other batteries possessing ever higher energy densities.

Electric Propulsion—a Game Changer

Early in the design of propulsion plants, reciprocating steam engines were introduced as one of the first means of mechanized propulsion on ships, gaining popularity in the late 1800s. Advancements in materials, science, and precision manufacturing processes enabled development of the steam turbine, which increased the fuel efficiency of the steam plant. However, the steam turbine's output shaft rotated at a significantly higher speed than that of the reciprocating steam engine—thousands of revolutions per minute in comparison to mere dozens. Due to the high shaft speed, steam turbines could not be directly connected to propulsion shafts without disastrous consequences.

Two methods were developed to facilitate the use of steam turbines on vessels: electric propulsion power from turbine generators, and use of reduction gears to connect the turbine output shaft to the propulsion shaft.

Electric motors are desirable, as they provide high torque at low speeds with no loss in efficiency, as compared to internal combustion engines, which drop significantly in efficiency when operated at low speeds. Due to the increased fuel efficiency and the convenience of flexible arrangements within the vessel's hull, electric propulsion is gaining popularity with vessels that demand high torque at low speeds. Towing vessels, offshore supply vessels, passenger vessels, icebreakers, and research vessels often fit this category.

According to Dr. John Warner,[1] a hybrid electric vessel is capable of reducing its fuel consumption by 15 percent to 25 percent—a further reduction from current diesel-electric configurations. Using traditional diesel-electric plants with azimuth pods drives, a vessel would only obtain 5 percent to 15 percent fuel savings.[2] This noticeable increase in fuel savings that lithium-ion batteries provides is a significant incentive for vessel operators to choose more innovative strategies to comply with increasingly stringent emissions regulations and reap the benefits of lower fuel costs.

Electric propulsion systems operate with lower noise and less vibration, which can be particularly beneficial for vessels that carry passengers, conduct research with sensitive instruments, or operate in delicate environments.

Hybrid electric vessels are capable of reducing emissions by operating internal combustion engines at optimal loads. All-electric vessels are capable of reducing exhaust stack emissions to a bare minimum—and potentially to zero when the vessel is charged via shoreside infrastructure. Ultimately, hybrid electric and all-electric vessels are a growing trend in a maritime industry that is looking to reduce its environmental footprint.

Game-Changing Emissions Regulations

Over the last 11 years, emissions regulations published by various state, federal, and international agencies—including the Environmental Protection Agency and the International Maritime Organization (IMO)—have continued to require more stringent limits on exhaust stack emissions. These limits are specifically focused on greenhouse gases and combustion byproducts that are damaging to the environment and human health, including nitrous oxides, sulfur oxides, and particulate matter. The intent of limiting these emissions is to decrease the local and global impact vessels have on air pollution and climate change.

In 2013, IMO regulations came into force requiring certain vessels to have an International Energy Efficiency Certificate, which includes a requirement to calculate the energy efficiency design index (EEDI) of the vessel. The EEDI is a measurement of a vessel's energy efficiency based on vessel type, cargo capacity, and the amount of fuel it carries. It is a performance-based requirement that incentivizes fuel-efficient vessel designs in an effort to further limit the environmental impact of ships. The sum impact of these regulations is that there is increased interest in electric propulsion using integrated power systems.

Electric Propulsion—Advantages and Incentives

Complementing increased fuel efficiency, electric propulsion plants increase the flexibility of vessel arrangements. This flexibility transforms traditional machinery space design, location, and volume.

In traditional mechanical drive propulsion plants, a large portion of the ship—from about amidships to the stern—is consumed by the engines, reduction gear, and long propulsion shafts. For electric propulsion, up to a 30 percent reduction in machinery space volume is possible,[3] allowing for more passengers, cargo, or equipment related to a vessel's specific service—or enabling the use of a smaller ship. Simply put, this translates into more usable space with less broken stowage, and increased revenue due to lower operating costs.

Furthermore, machinery spaces can be designed with more flexibility. For example, a vessel might have a forward engine room or a series of machinery spaces throughout the vessel rather than one enormous machinery space. Additional benefits include the optimization of vessel arrangements for stability and structural concerns.

Electric propulsion systems operate with lower noise and less vibration, which can be particularly beneficial for vessels that carry passengers, conduct research with

Dock electric power supply pedestal. Photo by David M G / Shutterstock.com.

sensitive instruments, or operate in delicate environments. Less noise and vibration also reduces crew member fatigue—a leading cause of accidents. Reduced noise pollution is also desirable near urban areas, lessening demonstrable negative effects on human health.

Further cost reductions may manifest in the vessel maintenance budget. Shaft alignment, lubricants, and replacement parts are major costs on vessels equipped with reciprocating engines. Removing large sections of hull plating to replace large pieces of equipment is yet another major cost associated with maintenance.

Integrated power systems enable the use of a variety of propulsion technologies, including azimuth pods and Voith Schneider propulsion units, in addition to the more traditional propulsion motors. Azimuth pods, in particular, provide increased redundancy and maneuverability. This is particularly desirable for cruise ships, as the pods enable docking and maneuvering without the need for assist tugs, making these frequent operations less expensive and potentially safer. Dynamically positioned vessels benefit from multiple thrusters, as well. The redundancy ensures the vessel can maintain station during critical operations, even if a casualty occurs to a single thruster.

[T]he time a mariner has available to react and take corrective, mitigating, or emergency actions will be significantly less with these systems compared to what mariners are used to with traditional mechanical systems.

Electric Propulsion—Challenges

There are numerous incentives for choosing electric propulsion powered by integrated power systems, but that doesn't necessarily mean it's the best solution to power plant and propulsion needs on all vessels. Vessels primarily operating at their full-rated speed are prime examples. Traditional power plants are much more efficient in this scenario.

Another weakness of all-electric propelled vessels is that they are range-limited due to battery capacity and do not have the flexibility to change their route or operation without significant foresight. This range is determined during the design phase and is used to size the battery banks. Conceivably, battery packs could be switched out in the future as the chemistries become more energy dense, but, as auto manufacturers are discovering, this is probably easier said than done—particularly in the marine environment.

Additionally, the consideration of the vessel's charge and discharge cycle with regards to the associated battery's state of charge remaining within design parameters is vital to maintaining full confidence in the operation of the vessel.

Another easily overlooked challenge is the increased complexity of an integrated system. Integrated power systems eliminate the division between the power system and propulsion system that often provided mutually exclusive safety layers in the past. With mechanically driven propulsion plants, a failure of either the auxiliary generators or the propulsion plant usually did not have the potential to disable the other, but that is not the case with an integrated electric power system. A single fault to the integrated bus[4] has the potential to result in failure to the entire system, meaning the loss of propulsion and electric power are no longer mutually exclusive events.

Moreover, the increased complexity of integrated power systems is likely to challenge vessel operators. Having an intimate understanding of electronic automation systems and controls requires a level of knowledge that mariners with limited licenses are not expected to have. For example, computer programming or electronic control theory is not a skill assessed in formal licensing training below the first assistant engineer unlimited horsepower level. Therefore, automated systems become "black boxes" to the operators and are often required to be serviced by specialized technicians from the system's manufacturer rather than the vessel's crew.

The black box issue can result in complacency, disregard for the manufacturer's recommendations, or even aversion to understanding the system, especially when it works properly hundreds of times. The lack of awareness in one instance, like ignoring a nuisance alarm, can quickly change a normal scenario into a dangerous event, as the time constant[5] of an electrical system is significantly less than a mechanical time constant. Electrical time constants are generally on the order of microseconds. Any change to the electrical system, whether through internal influence (e.g. electric fault, etc.) or human input (e.g. throttle movement, helm movement, etc.), results in a nearly instantaneous output—desired or undesired. An undesirable input, like an incorrect or accidental engine order or steering, is likely to result in a casualty.

Thus, increased focus on user-friendly and reliable automation systems, increased training, elevated situational awareness, and improved operator precision are all necessities when using complex electrical systems. Simply put, the time a mariner has available to react and take corrective, mitigating, or emergency actions will be significantly less with these systems compared to what mariners are used to with traditional mechanical systems. These issues are likely to be compounded on vessels that traditionally operate without licensed engineers, such as the small passenger vessel fleet.

Small passenger vessel operators have the potential to encounter a steeper learning curve due to the complexity of these systems. Knowing these challenges are present, the larger commercial maritime industry, with oversight from the USCG, must design automation systems with the aforementioned challenges in mind to alleviate an increasingly complex burden on mariners. Currently, all of these game changing issues are challenging owners, operators, and the Coast Guard to establish appropriate levels of safety while facilitating commerce.

Regulatory and Safety Challenges

Lithium-ion batteries provide an energy storage system that enables the design of hybrid electric and all-electric vessels, but the technology challenges the Coast Guard from a regulatory and safety standpoint. Current regulations in Title 46 of the Code of Federal Regulations do not address hazards or risks associated with lithium-ion batteries. The regulations were drafted when the majority of batteries used on vessels were lead acid batteries with safety hazards—very different from lithium-ion batteries.

Currently, the Coast Guard is most concerned with the thermal runaway hazard associated with these chemistries. Thermal runaway is the fire or explosion that happens when an internal short circuit in the battery causes initial ignition. In 2012, a U.S.-flagged towing vessel and Boeing's 787 Dreamliner aircraft experienced thermal runaway events. This phenomenon has also occurred in consumer electronics, like hoverboards and Samsung's Galaxy Note 7 Smartphone. One by one, these events are disrupting the proliferation of such technology on vessels.

Following much research and discussion with industry stakeholders, the Coast Guard is more prepared to deal with this risk on commercial vessels. Specifically, the USCG Marine Safety Center is conducting case-by-case plan reviews using a two-layer safety strategy. The first layer involves preventing thermal runaway by requiring the use of a manufacturer-recommended battery management system that is integrated properly with the other automation systems necessary for these vessels to operate. The second layer involves mitigating the risks associated with a fire, should it occur.

This two-layer system is particularly challenging for the design and operation of small passenger vessels of fewer than 100 gross tons carrying 150 passengers or fewer. Those regulations for traditional small passenger vessels were not designed with structural fire protection, and do not usually require automation test procedures, as discussed in Title 46, Code of Federal Regulations, Subchapter F. These issues have changed the game significantly, and the increased regulatory scrutiny is necessary to ensure the public's expected safety level is met.

A mobile phone, powered by a lithium-ion battery, explodes and burns due to overheating, a potential danger when using smartphones. Photo by wk1003mike / Shutterstock.com.

The Future

As recently as 10 years ago, the automotive industry was not convinced that all-electric or hybrid vehicles were viable. The Toyota Prius was introduced in 1997, but it took another decade for other auto manufacturers—and consumers—to catch on. Now, 20 years later, almost all car companies have a hybrid and/or electric vehicle, and parking lots across the globe are installing charging stations. Tesla has demonstrated the viability of manufacturing only electric cars. The Coast Guard is expecting to see a similar movement in the maritime industry.

As vessel designers continue to find new ways to meet the challenges of emissions regulations, the industry and the Coast Guard will certainly face more game-changing events. Whether hybrid electric vessels or all-electric vessels are the future, dealing with the challenges our industry faces is what has sustained the U.S. maritime industry since our nation's earliest years. Electric propulsion using integrated electric power systems is a vital option as we continue to grow the nation's maritime industry with vessels that are easily monitored, safe, reliable, and more environmentally friendly than the previous generation.

About the Authors:

LT Kate Woods currently serves as chief of the Inspections Division at MSU Chicago. She joined the Coast Guard nine years ago after graduating from the U.S. Merchant Marine Academy. She has previously served as a marine inspector in Seattle, completed one master's degree in marine engineering and naval architecture and another in mechanical engineering at the University of Michigan, and served at the USCG Marine Safety Center in the machinery branch.

LT Steven Lewis has served for eight years in the Coast Guard as a deck watch officer, marine inspector, and marine safety engineer. He is a graduate of the Coast Guard Academy and recently earned a master's degree in electrical engineering from Texas A&M University, concentrating in power systems and power electronics.

Endnotes:

1. John Warner, 2015, *Handbook of Lithium-Ion Battery Pack Design.*
2. Mukund R. Patel, 2012, *Shipboard Propulsion, Power Electronics, and Ocean Energy.*
3. Ibid.
4. A bus, also known as a bus bar, is a metallic strip or bar housed inside of an electrical panel and is used for high current power distribution.
5. A time constant is a unit of time that represents the speed with which a particular system can respond to change. In this case, we wish to point out that electrical systems respond in microseconds, while mechanical systems take seconds or even minutes to respond.

Liquid Hydrogen

A pathway to zero-emissions, renewable vessel power

by Mr. Timothy E. Meyers, P.E.
Office of Design & Engineering Standards
U.S. Coast Guard

3-D rendering of the *SF-BREEZE*, a hydrogen fuel cell-powered, high-speed passenger ferry. Image courtesy of Sandia National Laboratories, from the Sandia Report SAND2016-9719, October 2016 (see bibliography).

In February 2016, a multidisciplinary gathering of 45 representatives from the maritime industry and federal government converged on Department of Transportation Headquarters in Washington, D.C., to explore the benefits, challenges, and feasibility of using hydrogen fuel cells to power shipboard propulsion and auxiliary systems.

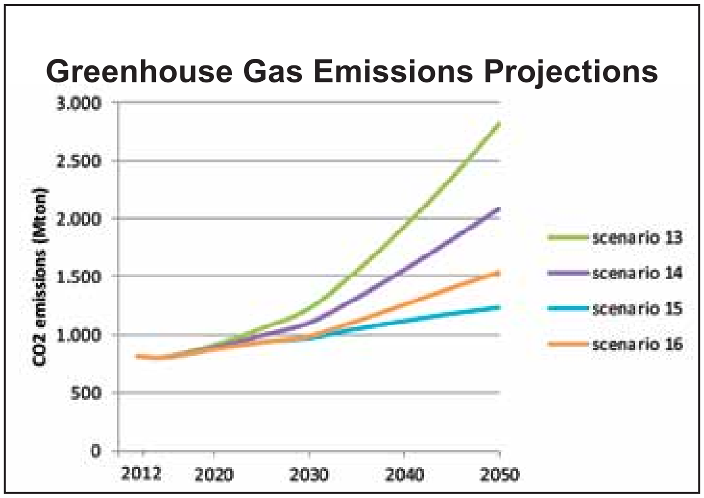
Sandia National Labs hosted this zero-emission hydrogen vessel workshop, which the U.S. Maritime Administration (MARAD) sponsored under its Maritime Environmental and Technical Assistance (META) program. META promotes the research, demonstration, and development of technologies and processes that improve maritime industry environmental sustainability. The aim of the meeting was twofold: assess the challenges in using hydrogen fuel cell technology on a variety of vessels, and develop a roadmap to realize its widespread implementation.

But why this sudden interest in hydrogen and fuel cell technology? Liquid hydrogen holds the promise of providing a pathway to achieving zero-emissions and renewable power—a potential game changer in the fight to combat greenhouse gas (GHG) emissions, decrease air pollution, and reduce dependency on our limited global supply of carbon-based fossil fuels.

Rising Concern

According to a 2014 International Maritime Organization (IMO) study, GHG emissions from ships are not only on the rise, but projected to increase from 50 percent to 250 percent by the year 2050. The main driver for these increases is a projected rise in demand for marine transportation. With emissions from maritime transport activity accounting for 2.8 percent of the total global GHG emissions—the 2007–2012 average—shipping's environmental impact is not insignificant.

In recent years, the IMO has implemented several regulatory regimes under the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI



Greenhouse gas emissions projections (in CO_2 equivalents) for various "business as usual" transport demand scenarios. These scenarios assume current policies on energy efficiency and emissions of ships remain in force, and that no increased stringencies or additional policies are introduced. Graphic from the Third IMO GHG Study 2014 (see bibliography) courtesy of the International Maritime Organization.

to address the problem of shipboard air emissions. They include:

- Placing global limits on sulfur content in fuel;
- Limiting nitrous oxide emissions from diesel engines;
- Establishing emission control areas along the coasts of North America, Northern Europe, and Scandinavia;
- Implementing Energy Efficient Design Index requirements to reduce emissions through more energy-efficient vessel design.

While these programs are expected to mitigate emissions growth, the IMO study shows they are not enough to produce downward GHG trends as long as carbon-based fossil fuels remain the dominant energy source.

Our current dependency on non-renewable energy sources is also a major cause for concern. According to estimates published in BP's 2016 Statistical Review of World Energy, it will only take about 50 years to completely deplete the world of its known oil and natural gas. Therefore, the long-term outlook for traditional marine fuels is in real jeopardy.

The ultimate solution to these concerns is to identify technologies that can deliver zero emissions while simultaneously eliminating dependency on non-renewable fossil fuels. Once identified, such technologies still require time and resources to develop, optimize, and implement. With the clock ticking for environmental and sustainability issues, the time to act is now.

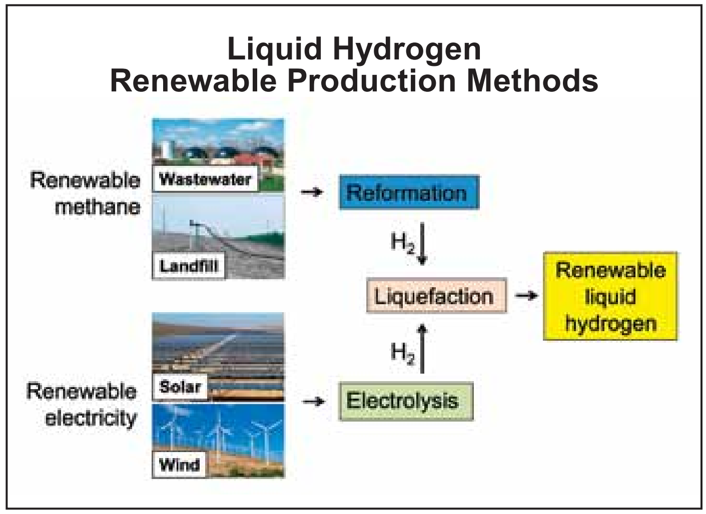
The Case for Renewable Liquid Hydrogen

One approach to the problem gaining some momentum through efforts like the MARAD-sponsored workshop is the use of liquid hydrogen as a fuel source, coupled with fuel cell technology. If created through renewable means, hydrogen acts as a storage and transport medium for renewable energy that can be converted to shipboard power through clean, energy-efficient fuel cells.

In considering the potential environmental impact of any proposed solution, it is important to not only address emissions at the point of use, but to take a holistic life cycle approach, as well. In the land-based transportation industry, this is often referred to as a "well-to-wheels" analysis, assessing the environmental impact from initial production of the fuel, to its delivery to the service station, to its transfer into a vehicle's fuel tank, and then ultimately to its use powering a vehicle. In the same way, when considering marine applications, we can think of this as a "well-to-wake" approach.

A hydrogen fuel cell, in the simplest sense, takes hydrogen and combines it with oxygen to produce electrical current, heat, and water vapor through the following electrochemical reaction:

$$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (g)$$



Example pathways for renewable (zero-GHG) liquid hydrogen production based on steam methane reforming, biomethane feedstock, or electrolysis of water using renewable electricity. Image courtesy of Sandia National Laboratories, from the Sandia Report SAND2016-9719, October 2016 (see bibliography).

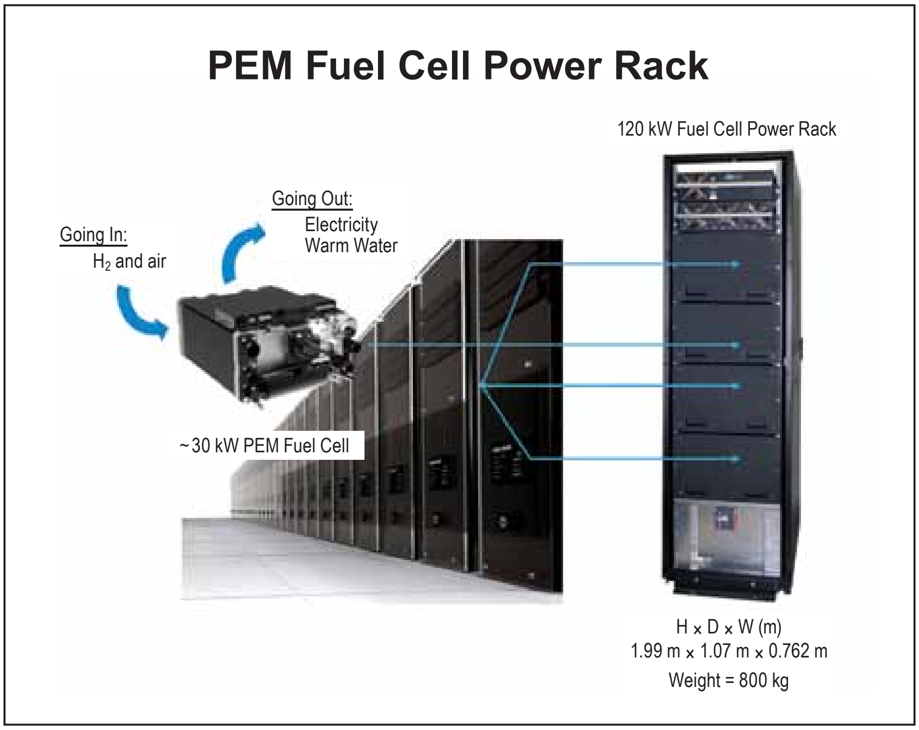
It is not enough to develop a power system that minimizes environmental impact onboard the vessel. We must also select and resource fuels in an environmentally responsible way.

Hydrogen is not a substance naturally found in nature. It cannot be mined, like natural gas. It must be created. Currently, hydrogen is primarily produced through the reformation of methane, usually obtained from natural gas.

Using hydrogen made from natural gas does nothing to reduce our dependency on fossil fuels, but if hydrogen is derived from methane taken from wastewater, landfill sources, or other renewable sources, it allows us to leverage these renewable energy sources in a portable form that can be used to fuel shipboard power and propulsion systems. Liquefying hydrogen then reduces its volume by about 850 times, making it more manageable to store aboard ships in sufficient quantities for shipboard use.

If our goal is to find an energy conversion technology that minimizes or even eliminates harmful emissions and, at the same time, does not rely on fossil fuels, then hydrogen fuel cells would seem a perfect fit.

To create electrical current, an electrochemical reaction is carried out in a fuel cell in much the same way as in a battery; through two half-reactions within the cell that are physically separated, setting up a flow of electrically charged ions. At the cell's anode, hydrogen is split into hydrogen ions and electrons. The hydrogen ions diffuse



Assembly of four Hydrogenics HyPM HD30 PEM fuel cells into a fuel cell power rack. Image courtesy of Hydrogenics Corporation.

through an electrolyte and combine with oxygen at the cathode to form water. This creates a flow of electric current between the cathode and anode. As long as fuel and air are supplied to the fuel cell, it continues to produce a constant flow of electrical energy.

Several types of fuel cells are commercially available today. They differ primarily in the electrolyte and catalysts used to carry out the electrochemical reaction. The type most often used in current automotive fuel cell development is the Proton Exchange Membrane (PEM) fuel cell.

Typical PEM fuel cells use a solid proton-conducting polymer membrane as their electrolyte material and a platinum catalyst to facilitate the reaction kinetics. Their only outputs are electrical current, heat, and water vapor. Compared to other fuel cell types, PEM fuel cells offer high power density, high efficiency, good transient performance, and are relatively compact, making them a good candidate for shipboard power applications.

Notable Progress

The maritime industry appears to be a long way from realizing full well-to-wake, zero-emissions, renewable vessel power. But we are seeing many individual efforts underway in developing pieces that may eventually come together to realize that goal.

Leveraging LNG-Fueled Vessel Experience

Over the past 10 years interest has been building in the use of liquefied natural gas (LNG) as a vessel fuel, with close to 200 LNG-fueled vessels either currently operating or under production around the world. LNG and liquid hydrogen are both cryogenic, liquefied, flammable gases that exhibit many of the same safety risks for transportation and use in the marine environment. Therefore, much of the experience the maritime industry is now gaining with LNG as a vessel fuel can be leveraged into developing safe shipboard systems that would use liquid hydrogen fuel.

Advances in Automotive Fuel Cell Technology

Fuel cell technology development is also progressing within the automotive industry. Since the early 1990s, major world automakers have been working to incorporate fuel cell-powered vehicles into their product lines.

As auto manufacturers continue to pour resources into technological development, we can expect to see improvements in performance, efficiency, weight reduction, and material robustness. The eventual mass adoption of fuel cell vehicles should also result in cost reductions for fuel cells as they become more ubiquitous.

Liquid Hydrogen Containment Systems

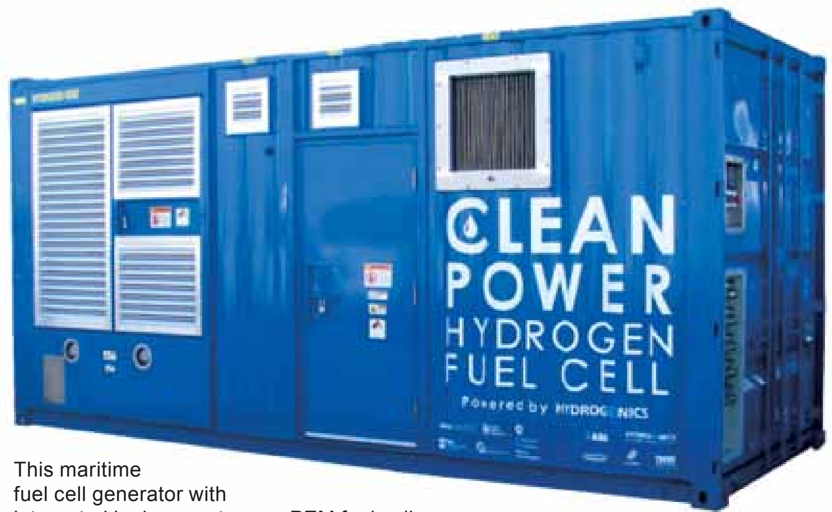
Pioneering advances in shipboard storage systems for liquid hydrogen, Kawasaki Heavy Industries is developing designs for a tankship that can transport hydrogen produced in the brown coal mines of Australia to consumer markets in Japan. This prototype liquid hydrogen carrier is designed to hold 2,500m^3 of cargo at a temperature of -252°C, or about 485°F, in two cylindrical tanks. While the propulsion system for this ship would use traditional diesel engines, there are plans to equip the vessel with fuel cells for auxiliary power that could operate on boil-off gas from the liquid hydrogen cargo tanks. Although applied on a much larger scale, the lessons learned in designing and constructing cargo containment and control systems for this prototype gas carrier should transfer over to storage and piping systems for hydrogen-fueled vessels.

Electrical Power and Control Systems

We are also seeing other technologies that use electrical power to gain traction in the battle against marine pollution. A number of projects around the country and the world employ batteries either alone or in combination with hybrid systems to provide auxiliary and propulsion power.

Examples include the *Hornblower Hybrid,* the *Tongass Rain* and the *Ampere.* The *Hornblower Hybrid* is a 65-foot San Francisco Bay passenger ferry outfitted with a solar array and wind turbines for augmenting power delivered to its two 400 HP electric propulsion motors. In its final design stages, the 50-foot passenger vessel *Tongass Rain* will be equipped with lithium-ion batteries to provide quiet, emissions-free ecotourism out of Juneau, Alaska. Operating emissions free in the fjords of Norway, the *Ampere* is the world's first all-electric, battery-powered car ferry.

These electrically powered vessels present their own unique challenges, but the knowledge gained in the marine application of power distribution and control systems could be applied to address similar needs on future fuel cell-powered vessel designs.



This maritime fuel cell generator with integrated hydrogen storage, PEM fuel cell power generation, and power inverter equipment can power up to 10 reefers with a total rated output of 100 kW at 240 VAC. Image courtesy of Sandia National Laboratories, from the Sandia Report SAND2017-5751, May 2017 (see bibliography).

Pulling the Pieces Together

Under their META initiative, MARAD has recently sponsored a number of projects aimed at stimulating interest in hydrogen fuel cell technology through research, development, and the demonstration of its use in practical marine applications.

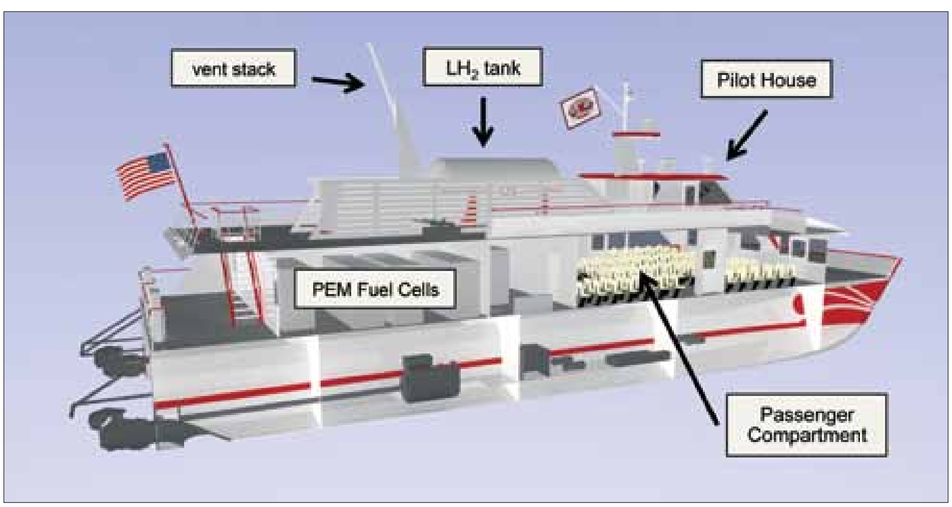
Maritime Fuel Cell Generator Project

In August 2015, MARAD launched field trials of a prototype fuel cell unit to power onboard refrigerated cargo containers. The unit, housed in a 20-foot shipping container, would replace standard diesel-driven containerized generator units that supply power to refrigerated containers shipped by barge between ports within the Hawaiian Islands. The fuel cell unit stores compressed hydrogen in a bank of cylinders that feeds racks of fuel cells located in a separate compartment within the container. The electricity generated is converted to AC power and distributed to up to 10 refrigerated cargo containers. A notable goal of this project is to gather real-world experience using hydrogen fuel cells in a maritime setting and evaluate how the system holds up in this specific environment. Lessons learned from this project will inform the development of future marine fuel cell projects.

SF-BREEZE *Feasibility Study*

Sandia Labs, in cooperation with Elliott Bay Design Group and Red and White Fleet, recently completed a MARAD-funded study to examine the feasibility of a high-speed passenger ferry powered solely by hydrogen fuel cells as well as its associated hydrogen fueling infrastructure within the context of the San Francisco Bay environment. The project team named their concept vessel the *SF-BREEZE*, which stands for San Francisco Bay Renewable Energy Electric vessel with Zero Emissions. The design settled on was a 109-foot, aluminum hull catamaran capable of carrying 150 passengers at 35 knots. Total installed power was 4.92 MW supplied by PEM fuel cells arranged in two separate fuel cell spaces. Liquid hydrogen was stored in a 1200kg capacity tank located on the upper deck.

In a September 2016 report, Sandia determined the project was feasible from a technical and regulatory standpoint. The technology currently exists to build and operate the vessel, and it is expected that methods could be found to mitigate regulatory



Engineering model of the *SF-BREEZE* as designed by Elliott Bay Design Group. The top deck holds the liquid hydrogen (LH_2) storage tank, the associated vent stack, evaporation equipment, and the pilot house of the vessel. The main deck holds the PEM fuel cell power racks and the passenger compartment. Image courtesy of Sandia National Laboratories, from the Sandia Report SAND2016-9719, October 2016 (see bibliography).

issues that might arise in the more detailed design stages. However, the economics of the *SF-BREEZE* as a high-speed ferry were significantly challenging, with an estimated increase in capital cost of 150 percent to 200 percent and operating costs of 300 percent to 1,000 percent more than a conventional diesel-fueled vessel. Those estimates are based on the current state of fuel cell and liquid hydrogen storage technology. With improvements in these technologies, the costs are expected to diminish considerably.

SF-BREEZE *Optimization Study*

As a follow-on to the *SF-BREEZE* Feasibility Study, Sandia is now undertaking a new project to examine other passenger vessel configurations that may be a better fit for today's fuel cell and hydrogen technology. The new study will explore development of several concept vessels with differing key parameters such as speed, hull material, size, and mix of passengers versus vehicles. The most favorable concept will then be selected for further detailed design and analysis.

Standards Development

A major hurdle in the acceptance of a liquid hydrogen fuel cell-powered vessel is obtaining regulatory approval to ensure the safety of the vessel, passengers, crew, and the marine environment. The good news is that an international standard exists that provides a regulatory framework for the safe design of gas-fueled vessels: the IMO's International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code).

The current version of the IGF Code was developed with detailed requirements specific to natural gas, with the understanding that additional requirements would be added for other low-flashpoint fuels as the need arises within the maritime industry. While the IGF Code is not specific to liquid hydrogen, it does contain overarching goals and functional requirements that can be applied to a vessel using any low-flashpoint fuel through the code's alternative design process.

Sandia's *SF-BREEZE* feasibility study took a close look at the IGF Code and found that since the properties of hydrogen are very similar to natural gas, many of the LNG-specific requirements in the IGF Code can be applied directly or adapted to address liquid hydrogen fuel. Furthermore, the IMO is currently working on amendments to the IGF Code that would also add requirements for the safe installation and use of fuel cells.

Another initiative that may prove beneficial is the IMO's recent adoption of "Interim Recommendations for Carriage of Liquefied Hydrogen in Bulk" on November 25, 2016. These provisional standards were developed to support the pilot project undertaken to ship liquid hydrogen produced from unused brown coal reserves in Australia to markets in Japan. These interim recommendations apply to liquid hydrogen carried as cargo not used as fuel. They may, however, provide good insight into addressing the risks common to both applications.

Conclusions

Following MARAD's workshop held in February 2016, many of the stakeholders that attended established a working group to continue the discussion on benefits, challenges, and feasibility of zero-emissions hydrogen-fueled vessels. The group is currently following the results of MARAD's META fuel cell projects, discussing results, and providing feedback on key issues that still need to be addressed. While widespread application of this technology may not be economically feasible in today's economic environment, it is clear that fuel cells and liquid hydrogen technology are poised to play a key role in solving our environmental and sustainability challenges looming in the near future.

About the author:

Mr. Tim Meyers is the Coast Guard's lead engineer on regulatory and policy development for the safe design of shipboard systems using liquefied natural gas and other alternative fuels. He represents the U.S. in development of the IMO's International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels *(IGF Code), as well as other related industry standards. Mr. Meyers has over 25 years of experience in enforcement, interpretation, and development of maritime safety and security regulations with the U.S. Coast Guard. He holds a bachelor's degree in applied science from the U.S. Coast Guard Academy, a master's degree in chemical engineering from the University of Virginia, and is a registered professional engineer.*

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Cyber Risk Management in the Maritime Transportation System

by LT Kevin Kuhn
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While unmanned ships and autonomous ports are technologically feasible, it will be quite some time before the global maritime community overcomes the fear and uncertainty associated with removing all human control of critical safety, security, and environmentally sensitive shipping operations. We do, however, stand on a precipice where technology has become an essential element of many onboard and shore-based systems that will continue to revolutionize the way shipping operations are conducted.

While the transition to increased dependence on cyber-enabled technologies occurs, the maritime industry must be proactive to maintain the outstanding safety record it has earned. The safety culture embedded in the DNA of our industry was developed over decades of carefully implementing risk management principles into all aspects of shipboard life. In the face of such rapid technological growth, it is this culture of risk management that will provide for a safe transition from the age of diesel to the age of the computer.

Cyber Vulnerabilities in the Maritime Transportation System

While cyber vulnerabilities in shipboard systems are alarming to experts, it takes an unusual skill set and precise timing to use these vulnerabilities to disrupt shipping operations or cause a serious marine casualty. TV shows like *Mr. Robot* and *Silicon Valley* introduce the realities of cyber threats to the general public, but the complexities of shipboard systems are unfamiliar to most opportunistic hackers.

GPS jamming, which is nothing new, is one such vulnerability. Jammers work by emitting a signal on the same frequency as a signal from the Global Navigation Satellite Systems (GNSS) at a close range, overpowering the authentic signal.[1] These devices are incredibly disruptive when operated in a densely populated area or near a mass transit hub. To disrupt shipboard navigation, a GPS jammer would have to be positioned in the proximity of the GPS antennas aboard the ship and operate during navigation of a restricted area. That said, disruption of the GPS signal would likely trigger an alert on the navigation system, prompting manual override of the autopilot. It is therefore unlikely that the disruption of a GPS signal could put a ship in a dangerous position, provided the watch officer was alert and acting in accordance with his or her training and procedures.[2]

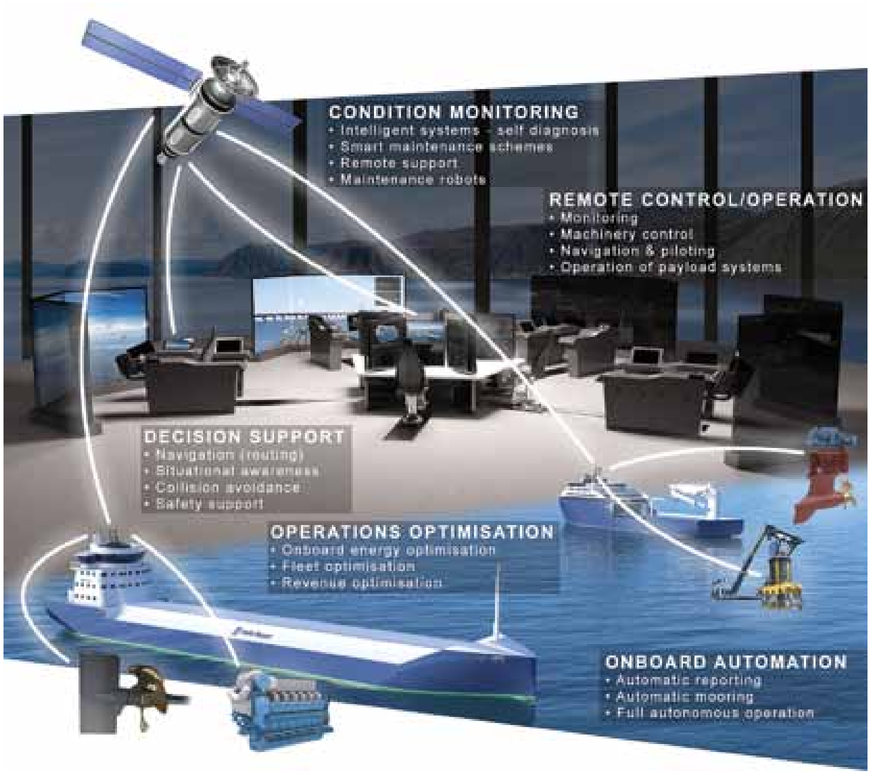
While this example is really a radio signal manipulation, not a cyber attack, it still portrays the risks of electronic navigation in a tangible example that reveals only the tip of the iceberg.

The voyage data recorder (VDR) is another device that has shown cyber vulnerabilities. A VDR is the shipboard equivalent of an aircraft's "black box," and essential during casualty investigations because it records numerous inputs like bridge audio and VHF communications; ship's position, speed, and heading; watertight and fire door status; radar, ECDIS, AIS, and echo depth sounder data; and other inputs, as required by U.S. and international regulations.[3]

It has been shown that hackers could manipulate data captured by the VDR.[4] For example, a malicious actor could use this vulnerability to cover up the cause of a marine casualty or to remove evidence of criminal activity aboard a vessel. Though the risks associated with VDR vulnerabilities may be minimal since VDRs don't directly control the movement of a vessel, such vulnerabilities could be magnified when planned in alignment with other malicious activities.

Cargo system manipulation is another area that could cause significant disruptions at a port facility during loading and unloading. It has been a proven method for smuggling goods into a port. This is accomplished by introducing malware that targets the cargo management system into the shipboard network. Once embedded in the cargo management system, the malware allows remote manipulation of the cargo manifest. This technique was used in 2013 to smuggle more than 1,000 kilograms of cocaine through the port of Antwerp.[5]

Ransomware is yet another effective tool for disrupting the shipping industry. This is a common technique where a virus is introduced into a shipboard network either using



This figure depicts a conceptual design by the Rolls Royce Ship Intelligence Project which shows the level of automation and connectivity that will likely permeate all aspects of ship design and control in the future. Photo courtesy of Rolls-Royce Marine.

phishing emails with attachments, drive-by downloading from the internet, or via a USB storage device. Any computer connected to the network is locked out unless a ransom is paid. There are increasing reports of shipping companies being infected. Some simply pay the ransom to maintain their operational schedule and reduce disruptions.[6]

Sometimes required by manufacturers for warranty purposes, remote monitoring and control of cargo and propulsion systems also present vulnerabilities, and are increasingly prevalent. Legacy operating systems are seldom updated, allowing for considerable vulnerabilities in operational equipment like engine monitoring systems and fire detection systems. While targeted malicious attacks are truly concerning, inadvertent introduction of malware is just as serious—and much more likely to occur. The nature of shipping operations requires numerous users to have access to critical systems, which increases the opportunity for the introduction of malware.

Communications, engineering, cargo control, ballast water management, safety, environmental control, and other systems are similarly vulnerable to such cyber attacks.

Why haven't we heard about these disruptions in the news? Well … we *have* occasionally, but perhaps we didn't take notice because they've only caused minimal disruptions to the maritime transportation system and haven't caused loss of life or significant damage to the marine environment. The risk management culture in the maritime industry has effectively reduced cyber-related risks to a manageable level—for now.

Cyber Risk Management in the Maritime Industry

Risk management addresses cyber-related risks by extending existing safety management techniques to cyber-enabled technologies. Risk management for cyber, much like any other operational risk, involves identifying risks, protecting against threats, detecting problems, responding to incidents, and recovering from an incident by implementing continuous improvement mechanisms.

Much the same as mariners would check the weather prior to departing on a voyage, they should also check cyber-dependent systems to ensure they are up-to-date and functioning properly. Similarly, one would consider safeguarding cyber systems from unauthorized access alongside other security measures, like locking exterior doors or posting a gangway watch in port. The deliberate implementation of a cyber risk management program should be decided by the shipping company and include guidance for personnel at all levels of the organization, from the CEO down to the deckplates.

Over the last five years, many organizations have sought to define how cyber risk management should be implemented on ships, and the overwhelming consensus has been to follow the Cybersecurity Framework developed by the National Institute of Standards and Technology (NIST). Developed

Interim Guidelines on Maritime Cyber Risk Management

Functional Elements:

Identify: **Define personnel roles and responsibilities for cyber risk management and identify the systems, assets, data, and capabilities that, when disrupted, pose risks to ship operations.**

Protect: **Implement risk control processes and measures as well as contingency planning to protect against a cyber event and ensure continuity of shipping operations.**

Detect: **Develop and implement activities necessary to detect a cyber event in a timely manner.**

Respond: **Develop and implement activities and plans to provide resilience and restore systems necessary for shipping operations or services impaired due to a cyber event.**

in 2014, the NIST framework defines five functional elements that create the backbone of a sound cyber risk management program.[7] The framework was designed to be generic so it could be employed by any sector, ranging from financial or medical to transportation or security. Groups within the maritime industry have worked from this framework to develop additional guidelines and best practices.

Complementing these efforts, the United States participated with 43 countries in the International Maritime Organization (IMO)'s Maritime Safety Committee (MSC) to develop IMO guidelines that would provide high-level recommendations to safeguard shipping from current and emerging cyber-related threats and vulnerabilities. The IMO guidelines were finalized in July 2017 as MSC-FAL.1/Circ.3 *Guidelines on Maritime Cyber Risk Management*. They implement the five functional elements detailed in the NIST framework, with the ultimate goal of embedding these elements into all aspects of company operations and personnel management in the same way industry has embraced safety culture with the adoption and implementation of safety management systems.

The establishment of the IMO guidelines was a significant milestone in the management of cyber risks in the maritime industry. These foundational guidelines, which provide organizations with the key elements for incorporating cyber risk management into existing safety management systems, also empower organizations to further develop best practices and additional implementation recommendations.

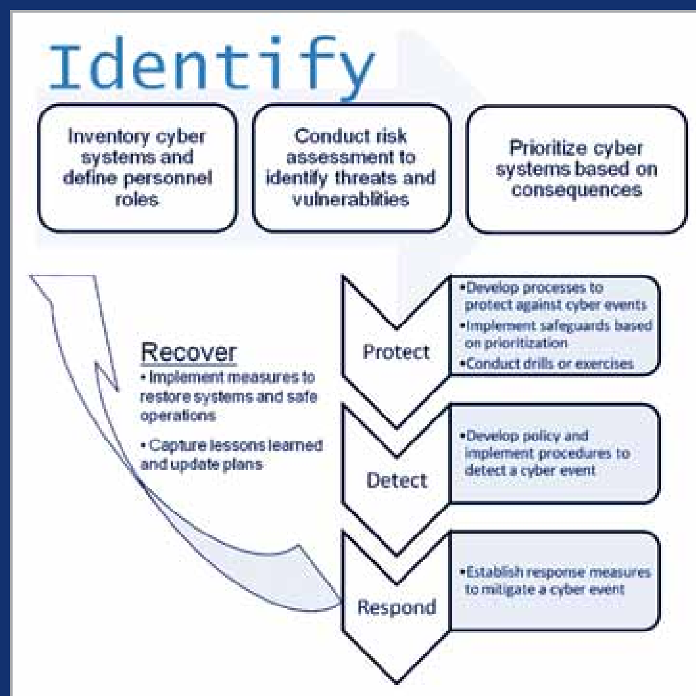
In June 2017, the IMO's Maritime Safety Committee published resolution 428(98) Cyber Risk Management in Safety Management Systems. This resolution affirms that cyber risks are required to be addressed by safety management systems and establishes a deadline of the first annual review of the company's Document of Compliance after January 1, 2021. This was the first compulsory deadline established in the maritime industry for cyber-related risks, and it is a critical step in protecting the maritime transportation system and the industry as a whole from the ever-growing array of cyber threats.

One industry publication highlighting foundational elements is *The Guidelines on Cyber Safety and Security Onboard Ships*.[8] Other guidance has been, and is still being, developed by classification societies and other industry associations. The industry as a whole is taking a proactive approach to embed cyber risk management into the existing safety culture before a significant incident occurs, prompting a costly regulatory approach.

Managing Cyber Risk

So what does a cyber risk management (CRM) program look like from a practical standpoint? It depends. The goal of the IMO guidelines is to leave the practical implementation up to the company, with compliance then being verified by a third-party organization, much the same as existing safety management system practices.

The outline below provides an overview of some risk management activities that could be included in an effective cyber risk management program. The key is to embrace a holistic cyber risk management culture into all levels of the company, with processes for continuous improvement and training, rather than simply installing something like anti-virus software on the computers.



Primary actions essential for a shipboard cyber risk management program. This cyclical process ensures continuous improvement and flexibility to adapt to changing threats and evolving technologies. Graphic courtesy of author.

Coast Guard Cyber Risk Management Awareness

Signed in June 2015, the Coast Guard Cyber Strategy identified three strategic priorities:

- defending cyberspace
- enabling operations
- protecting infrastructure

Conceptually envisioned by Rolls-Royce in the Advanced Autonomous Waterborne Applications Initiative, remote-controlled cargo ships could operate anywhere in the world. Photos courtesy of Rolls-Royce Marine.

Under the Assistant Commandant for Prevention Policy (CG-5P), the focus is on the "protecting infrastructure" priority. Offices within the Coast Guard Headquarters Prevention Directorate (CG-5P), in collaboration with other headquarters directorates and Coast Guard field units and the staffs for the area and district commanders, have made great strides in support of this priority.

These efforts employ two simultaneous lines of effort to implement a CRM regime in the maritime domain through the development of appropriate standards predicated on operational risk management. Vessel-focused CRM is approached from an international perspective through IMO, with an explicit association to the International Safety Management Code paralleling safety management requirements for physical shipboard systems. This includes the use of cyber standards, rules, and guidelines from classification societies. Facility-based CRM is approached from a domestic perspective, employing existing authorities under the Maritime Transportation Security Act, which requires operational risk management.

Shipboard CRM efforts at IMO emphasize the connection between CRM and existing safety management system structures. Following the Maritime Safety Committee's recommendations published in MSC-FAL.1/Circ.3, efforts now focus on implementation of the guidelines into safety management systems industrywide. Additional work will also be done to encourage industry organizations to further develop their programs and guidance based on best practices. Training for Coast Guard personnel will be necessary to ensure uniform enforcement and outreach efforts throughout the marine safety community.

Facility-based CRM is being advanced through industry outreach, a Navigation and Vessel Inspection Circular, and collaboration with industry and government partners. The Coast Guard's Office of Port and Facility Compliance is making great progress collaborating with area maritime security committees to leverage industry partnerships. Collaboration with other government agencies has also helped to advance progress toward the protecting infrastructure strategic priority.

Collaboration with the National Institute of Standards and Technology has focused on developing customized profiles of the cybersecurity framework. Such profiles provide tools that allow organizations to apply the NIST cybersecurity framework to their specific operational needs.

The first profile, published in 2016, centered on bulk liquid transfer operations and provides a guide for operators and owners of bulk liquid enterprises to develop a cyber risk management program based on the NIST cybersecurity framework.

Two additional profiles—mobile offshore drilling units and passenger vessel/terminal operations—are nearly

Envisioned by Rolls-Royce in the Advanced Autonomous Waterborne Applications Initiative, a land-based control center could navigate a remote-controlled cargo ship anywhere in the world.

complete. The next profile scheduled for early 2018 is for Electronic Navigation and Automation Systems on Vessels and Facilities. The profile development is a very successful means for establishing an open dialogue between industry experts and government representatives in order to advance the cyber posture of all participants.

The Future of Cyber-Dependent Shipping Operations

The future of cyber risk management depends on its effectiveness and ability to gain the trust of the maritime community and the public.

While in recent years we have seen the development of the smart home and self-driving cars, the shipping industry is similarly poised to take the technological leap to the "intelligent ship." Rolls-Royce has shown in concept, through their Advanced Autonomous Waterborne Applications Initiative, that the future of a minimally manned or even remote-controlled maritime transportation system will be feasible in the near future.[9]

Though it's unlikely an unmanned commercial ship will transit under the Verrazano Bridge any time in the next decade, it isn't the technology preventing it from happening. Rather, it's the need to ensure the technology is safe, operators are trained to use it properly, and stakeholders are confident it can be deployed with a minimum risk of incident.

The stakes are great, since a cyber incident at sea involving a remotely operated ship could potentially lead to a serious marine casualty. However, relying on the safety and risk management culture embedded in the maritime industry, cyber risks for systems on these types of ships can be minimized, allowing for the safe transition to occur in the not-so-distant future.

About the author:

LT Kevin Kuhn is a staff engineer in the Office of Design and Engineering Standards at Coast Guard headquarters in Washington, D.C. He is a 2008 graduate of the U.S. Coast Guard Academy, with a Bachelor of Science in naval architecture and marine engineering, and a 2015 graduate of the University of South Carolina, where he earned a master's degree in electrical engineering. His tours include Sector Charleston and USCGC Morgenthau.

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Critical Observations for Maritime Operations

Waves and surface currents

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NOAA/U.S. Integrated Ocean Observing System

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Engineer Research and Development Center
U.S. Army Corps of Engineers

Maintaining ocean observation infrastructure is critical to assuring the safety of our maritime community, promoting the economic health of maritime transportation, and protecting our environment.

The observation of waves is essential for ship operations and ship planning, as trends show that vessel length and draft are increasing, resulting in less under keel clearance to the sea floor. Additionally, tracking surface currents is a

This "receive" antenna from a CODAR Ocean Sensor 5MHz SeaSonde system, installed at the Scripps Institution of Oceanography, La Jolla, California, is an example of a coastal installation. Photo courtesy of the Southern California Coastal Ocean Observing System (SCCOOS).

necessity for search and rescue, oil spill tracking, port and harbor operations, and recreational boating.

Wave and surface current information is integrated into National Oceanic and Atmospheric Administration (NOAA) operational products like the Physical Oceanographic Real Time System® and the National Weather Service's (NWS) Advanced Weather Interactive Processing System. Weather forecasters use the surface current data to improve their daily marine forecasts and determine whether currents are wave-following or wave-opposing, which is key to understanding whether the local wave height may be reduced or enhanced, respectively.

Wave and surface current information is also used to identify spatial extents and trajectories of surface-following marine larvae populations, which assists with evaluating marine protected areas and tracking coastal plumes and discharges for water quality management.

The Coastal Data Information Program (CDIP) and the Coastal Observing Research and Development Center (CORDC), based at the Scripps Institution of Oceanography (SIO) in La Jolla, California, participate in near real-time data feeds of operational information for maritime operations. CDIP, primarily funded by the United States Army Corps of Engineers, focuses on ocean wave measurements. The CORDC provides data acquisition and near real-time processing of the national High Frequency Radar Network (HFRNet) established to measure surface currents throughout the U.S. coastal ocean waters. It developed and has operated data management for integration, distribution, and visualization of HFRNet surface currents for more than 10 years.[1] Central repository nodes are maintained on the East Coast by Rutgers University, on the West Coast by SIO, and at the National Data Buoy Center (NDBC), demonstrating an end-to-end data system linking multiple regions to a central data repository.

Wave and Surface Current Measurement Program

Wave Program Overview

CDIP has provided publicly available, high-resolution, reliable wave measurements since it was founded in 1975.[2] By 2016, CDIP disseminated the data for 65 coastal wave buoys, many of them at entries to ports and harbors, supporting near shore navigation.

A buoy transmits data every 30 minutes to the Department of Defense gateway in Honolulu, then it goes back to Scripps for analysis and quality control. Finally it is disseminated to the NDBC, where an identification number is assigned and the data posted on their website while also being transmitted to the NWS for marine broadcast. All historic data are available in network Common Data Form (netCDF) or text formats, with the appropriate metadata. The data are accessible via web services from the CDIP website or from the federal archive at the National Centers for Environmental Information (NCEI).

Directional Wave Measurements

Global and regional wave observational requirements are dependent on the application, and include:

- assimilation into wave forecast models
- validation of wave forecast models
- ocean wave climate as well as its variability on seasonal to decadal time scales
- the role of waves in ocean-atmosphere coupling.

Additionally, wave observations are necessary for short-range forecasting and nowcasting, as well as for warning about extreme waves associated with extra tropical and tropical storms. *In situ* wave observations are also needed for calibration/validation of satellite wave sensors. The key observations needed are:

- significant wave height
- dominant wave direction
- wave period
- 1-D frequency spectral wave energy density
- 2-D frequency-direction estimators (e.g., directional moments).

Also important and desirable are observations of individual wave components—sea and swell.

HF Radar Surface Current Program

Local, state, regional, and federal discussions directed towards the U.S. Integrated Ocean Observing System (IOOS) emphasized a desire for the installation, development, and operation of a network of surface current mapping systems for a broad range of users. This network not only brings

Where Data Aggregators are Currently Deployed

Scripps Institution of Oceanography
Rutgers University
University of Southern Mississippi
Monterey Bay Aquarium Research Institute
University of Miami—Rosenstiel School of Marine and Atmospheric Science
University of Maine
Oregon State University—College of Oceanic and Atmospheric Sciences
University of California, Santa Barbara
San Francisco State University
California Polytechnic State University

together and synthesizes physical data, but also builds relationships throughout the oceanography community.

The HFRadar Network started at SIO in 2004 as a prototype with data collected from local radars, as well as systems installed by Rutgers University and the University of California at Santa Barbara. The network has since grown into an operational system with contributions from 31 organizations collecting data from 130 radars. To date, more than 9 million radial files have been collected, contributing to 10 terabytes of radial and near real-time total vector products.

Central to the operational success of a large-scale network is an efficient data management, storage, access, and delivery system. The surface current mapping network is characterized by a tiered structure extending from the individual field installations of HF radar equipment—a site—a local regional operations center which maintains multiple installations—an aggregator—and centralized locations which aggregate data from multiple regions—a node.[3]

The architecture of the HFRadar Network lends itself well to a distributed real-time network and serves as a model for networking sensors on a national level. This joint University-IOOS partnership is focused on defining and meeting the expressed needs for a national network of surface current mapping data systems.[4]

HF radar-derived surface current data are made available through online visualizations; an advanced programming interface, which can be incorporated into any web

Case Studies

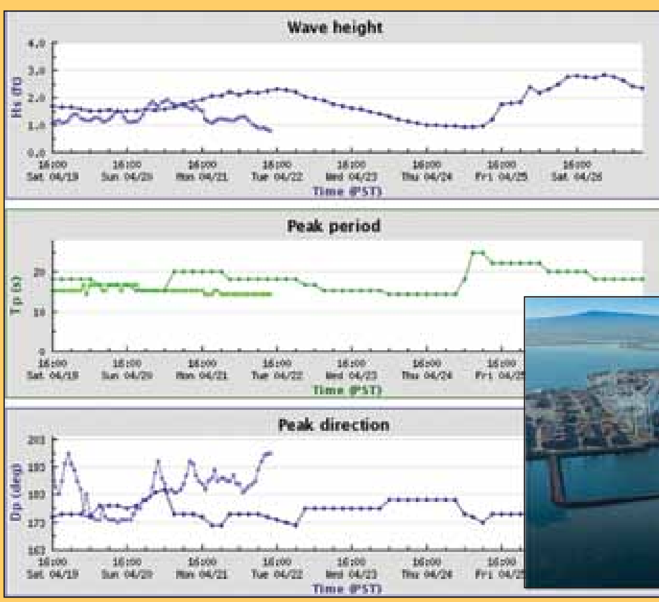
Where are high-resolution wave observations essential?

Entrances to ports and harbors

Maritime trade has long defined our nation's identity, culture, and economy. International trade in the Pacific, especially, depends on direct access to world markets.

Wave measurements are used for ship operations, while wave forecasts are used for ship planning. This information is particularly essential, as trends show vessel length and draft are increasing, resulting in less under keel clearance (UKC) to the sea floor, making under keel clearance a critical issue. In support of safe and efficient operations, The Coastal Data Information Program and Southern California Coastal Ocean Observing System (SCCOOS) have developed customized products for areas in need of high-resolution observations like the Port of Los Angeles, Long Beach, and the mouth of the Columbia River.

The Los Angeles and Long Beach Harbor: Combined, the Ports of Long Beach and Los Angeles handle more than 40 percent of the nation's imports. More than $150 billion worth of goods move through each year just within the Port of Long Beach, which serves more than 140 shipping lines with connections to 217 seaports worldwide. The issue is how to keep the ports commercially viable with the increasing draft on trans-Pacific and Panamax cargo vessels.



Comparison of San Pedro Buoy real-time observations versus WW3 eight-day model predictions, Port of Long Beach, April 2014. Graphs courtesy of CDIP; photo courtesy of the Port of Long Beach.

Under keel clearance is defined as the minimum clearance available between the deepest point on the vessel and the bottom in still water. UKC is not only a concern in the harbor, but also for the approaches to the port complex—specifically before the federal channels and areas off to the side of the channels when escape routes are used, if required. At the Port of Long Beach, Jacobsen Pilots have noted that, because of their design, ultra large crude carriers are being impacted by 12–14 period energetic swells. In a 365-meter vessel, a 12–14 second swell approaching from the stern causes a one-degree pitch, which results in an increase of draft by 3.2 m. During large swell conditions, knowing when to change course before entering the federal channel with a least depth that exceeds the UKC is challenging.

Currently the channel at Long Beach is dredged to 19.812 m. The oil on the supertankers is lightered offshore, then transferred into port on the smaller vessels. However, the UKC on the vessels that do transit directly into port is monitored closely. The information the SCCOOS/Coastal Data Information Program (CDIP) transmits to Jacobsen Pilots, alerting of certain exceedance wave conditions, is just one of piece of assistance. If the waves are from the west, the significant wave height (Hs) is greater than 1m, and the wave view; and a web service—the Thematic Real-time Environmental Distributed Data Services Data Server—at both the SIO[5] and the NDBC.[6]

HF Radar-Derived Surface Currents

High-frequency radar systems measure radio waves scattered off the surface of the ocean. HF radar has proven to be an effective method for coastal sea surface current mapping for a number of reasons:

- The targets required to produce coherent sea echo using HF are surface gravity waves, which are well understood and nearly always present in the open ocean.
- Vertically polarized HF waves can propagate over conductive seawater via coupling to the mean spherical sea surface, producing measurement ranges beyond line-of-sight to about 200km offshore.
- Doppler sea echo at HF, under most wave conditions, has a well-defined signal from wave-current interactions that is easily distinguishable from wave-wave processes. This allows for robust extraction of current velocities.

It is primarily these three features, along with the spatial resolutions that are possible due to the frequency modulation discussed below, which place the HF band in a unique status for coastal current monitoring.[7,8,9]

period is greater than 12 seconds, a bulletin is sent to the pilots and to the Port of Long Beach cruise ships.

In order to keep our ports commercially viable, we must have up-to-date hydrographic surveys, knowledge of the ship specifications entering the port complex, and high-resolution wave observations and models that indicate real-time and forecast conditions.

The figure on the previous page shows the comparison of the eight-day global Pacific model WAVEWATCH III forecast and the observations from the CDIP San Pedro Buoy, which is moored close to the entrance channel. The user can then denote how accurate the WAVEWATCH III model is portraying the wave conditions and determine if the model is over- or underpredicting. This is critical knowledge for planning transits to and from the ports.

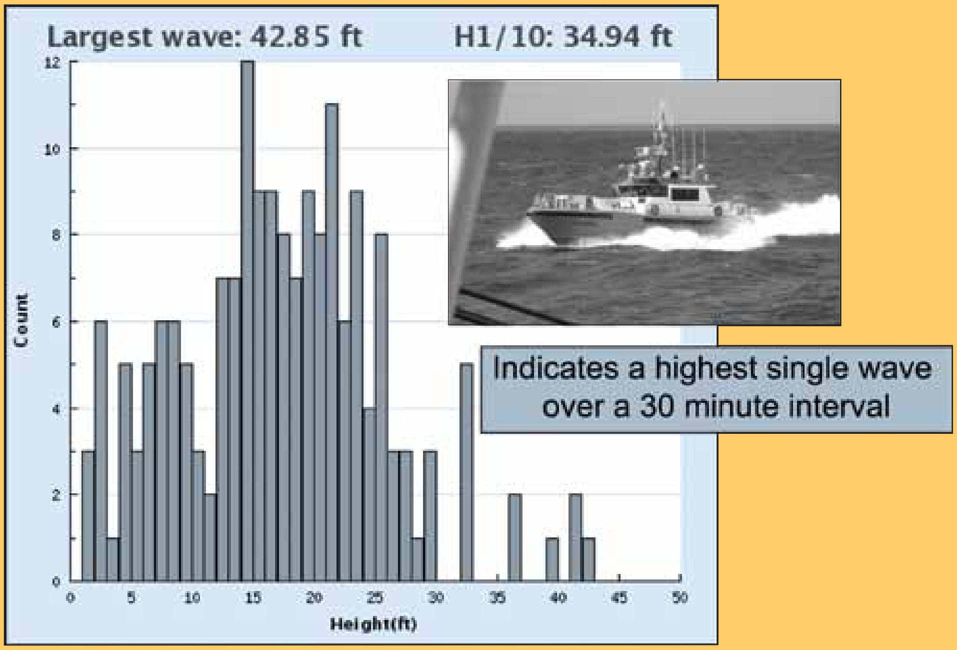
Mouth of the Columbia River: The UKC is of concern to commercial maritime traffic on the Columbia River, also. The federal navigation channel in the Lower Columbia River is 177 km long, and now 13.1m deep. The channel supports over 40 million tons of cargo each year, valued at $16 billion, and over 40,000 local jobs are dependent on this trade. This area is the number one bulk exporter in the U.S., including wheat and corn. The Pacific Northwest exports around 10 million metric tons of wheat annually.

Energetic wave conditions are one of the greatest challenges for this area. Since fall 2009, through partnerships with the U.S. Army Corps of Engineers in Portland, Oregon, and the Columbia River Bar Pilots, the Coastal Data Information Program maintains three buoys at this area. Two of the buoys are deployed, and one is configured but housed in a nearby warehouse, ready to deploy as a backup, as needed. One of the offshore buoys is deployed at the south entrance to the Columbia River, and the other is 43 km due west.

Information about the local seas is captured by the near-shore buoy, while the offshore Pacific swell data is captured by the off-shore buoy. The largest wave measured by the off-shore buoy was 17.25m at a 14-second period in December 2015. The largest wave at the near-shore buoy occurred in January 2014 and measured 14.24m at a 16-second period.

The figure below depicts the distribution of the spectral wave over a 30-minute

(continued on next page)



Histogram of wave height distribution over 30-minute time spans from the CDIP buoy at the mouth of the Columbia River, Pacific Northwest, United States. Graph courtesy of CDIP; photo courtesy of the Columbia River Bar Pilots.

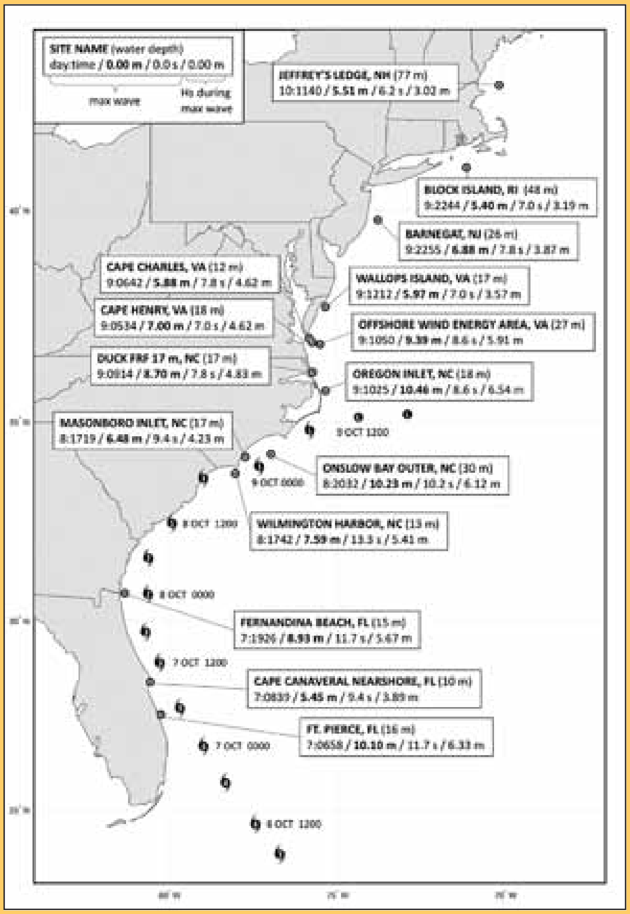
Land-based HF radar installations are located near the coastline and include one or multiple antennas, depending on the type and frequency of the system. A radio signal is broadcast across the ocean's surface, and the receive antenna(s) listen for the signal scattered by the ocean's waves.

Any deviation in Doppler shift from the theoretical wave speed is attributed to the surface current velocity. Because the radar measures these velocities in directions radial to the receive antenna, the surface ocean current measurements are called radial velocities. Data from neighboring antennas are aggregated through HFRNet, processed, and displayed to the user as surface currents maps showing velocity—speed and direction—in near real-time.

As noted earlier, there are a large number of users who require both wave and surface current information,

Case Studies

period. Requested by the Columbia River Bar Pilots, this information is useful during pilot transfers, as it gives the pilots an indication of how many wave "peaks" will occur during the 30-minute period. The pilots then have an idea about the timing when transferring to the commercial vessel.



Wave buoy locations, offshore eastern United States. Hurricane Matthew eye locations and storm intensities from NOAA's National Hurricane Center. All dates and times UTC October 2016. Graph courtesy of CDIP.

Tracking and validation of hurricane models

Providing real-time observations as validation for wave forecast models is essential, as seen in major hurricane events. During Hurricane Sandy in October 2012, the Coastal Data Information Program (CDIP) had 14 buoys along the East Coast, from the Caribbean to New Hampshire. The National Weather Service offices and emergency planners used these to monitor real-time conditions and validate the wave forecasts, noting whether the model predictions were accurate. These 14 buoys had 100 percent reliability during Hurricane Sandy. Wave models versus observations continue to be accessible on the CDIP and regional Integrated Ocean Observing System sites.

In October 2016, Hurricane Matthew occurred on the East Coast, and the 15 CDIP wave buoys along the coast displayed 93 percent reliability. The variances between the average and largest waves at each location underscore the importance of a robust wave observation network in coastal waters, where the impacts of coastal land and bathymetric features can cause large variations in waves over short distances.

Commercial fishing

Commercial fishing ranks among the deadliest professions in America, with a fatality rate 39 times higher than the national average. Between 2000 and 2010, more than 545 commercial fishermen died on the job.[1]

At the August 2014 California Ocean Observing Marine Symposium, long-time commercial fisherman, Peter Hansen, stated that the integration of data he now receives digitally greatly reduces his carbon footprint, and increases catch efficiency. The important thing, he added, is staying alive—many people have been lost due to the inability to access data, and that has changed drastically. "The Coastal Data Information Program and NOAA buoys and weather forecasting data aggregated and transmitted via satellites are literally a life saver. There has been a major decrease in deaths," he explained.

Endnote:

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Where are surface current observations essential?

U.S. Coast Guard search and rescue operations

Beginning in 2000, the U.S. Coast Guard Research and Development Center began a multi-year investigation into the utility of near real-time HF radar-derived surface current measurements for search and rescue. This assessment showed improved performance using radar-derived currents when compared against available National Oceanic and Atmospheric Administration tidal current predictions.

covering a broad range of complexity. Simple measures of wave height and period, to separations of the sea and swell components, to full 2-D spectral wave measurements for vessel response and shoreline erosion studies have value, depending on the operational scenario.

Similarly, integration of general surface current flow into products, like the short term predictive system (STPS) and oil spill forecasts (for future use in maritime domain awareness), are useful to a number of different organizations and agencies. Wave and surface current measurements help enable safe navigation, allow for economic growth, and can provide insight into environmental conditions in our changing world.

It is important to establish a consistent, common framework for these measurements that is scalable and accessible. The success and continued expansion of these networks

Additionally, a key element to using the HF radar currents was development of the Short Term Predictive System (STPS), a forecasting model that uses statistical information for surface current prediction. Following these evaluation studies, available in situ surface current velocities were used to evaluate and define appropriate parameters for integration in the USCG Search and Rescue Optimal Planning System (SAROPS) as the inclusion of HF radar currents significantly reduced the search area for USCG search operators.[1,2]

The University of Connecticut developed STPS and now operates the model, which runs automatically but has human technical support and troubleshooting on-call. Every hour, it creates a 24-hour forecast of current field evolution that is consistent with the most recent data as well as the statistics of the observed current variability. The STPS forecast is created by exploiting the periodicity of the tides and the fact that weather systems move slowly. The tidal part of the current can be predicted using traditional methods, and then the less-regular, weather-forced part can be isolated and extrapolated. Adding these parts together then results in a complete forecast of the currents.

The approach is applicable to any coastal area regardless of coastal geometry and bathymetry, and it does not make any assumptions about the underlying circulation dynamics. The primary advantage of this approach is that the algorithm can be readily applied with limited effort and expense in any area with an operational surface current data set.

Current velocities from HFRNet and the STPS forecasts are now included in the USCG SAROPS, as seen in the image below. Data is made available in an easily digestible format through web services that were previously mentioned in the HF radar program overview.

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HFRNet data flow for ingestion into the Search and Rescue Optimal Planning System (SAROPS) tool. Image courtesy of SCCOOS.

for the distribution of waves and coastal surface currents will be possible through the dedication and partnerships of multiple institutions, federal and non-federal agencies, local and state governments, and private companies.

It is important to combine these efforts and focus on interoperable products that are useful and freely available to everyone.

About the Authors:

We extend our thanks to the many authors who contributed to this article: Julie Thomas, Lisa Hazard, Mark Otero, and Eric Terrill (Scripps Institution of Oceanography); Robert E. Jensen (U.S. Army Corps of Engineers); Jack Harlan (NOAA/U.S. Integrated Ocean Observing System); and Todd Fake (University of Connecticut).

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Case Studies

Oil spill response

Once a spill has occurred, the first challenge is tracking its movement in response and mitigation efforts, especially in dark or foggy conditions. HF radar has the ability to track ocean surface currents during the night, in fog, or when conditions don't allow for direct observation of the spill.

In May 2015, a pipeline ruptured near Santa Barbara, California, spilling an estimated 101,000 gallons of crude oil. Southern California Coastal Ocean Observing System high-frequency radar-derived surface currents rapidly provided support to predict the trajectory of the oil spill in the ocean.

The next day, a temporary HF radar site was quickly installed by the University of California, Santa Barbara, to fill in coverage north of the spill and ran a local trajectory model adverting simulated particles through the current field to visualize the potential path of the slick. These surface currents were sent to NOAA's Office of Response and Restoration and the California State Office of Spill Prevention and Response to assist with operations.

In California, investigators participated in several exercises, including Safe Seas 2006, a NOAA-led multiagency simulated spill off the San Francisco coast, and the National Preparedness for Response Exercise Program simulation. These were held off the coasts of San Diego and Santa Barbara in 2008 and 2009, respectively. The simulations allowed the many state and federal regulatory agencies involved in oil spill response to practice working together in the event of an actual spill, and demonstrate the value of real-time surface current maps and forecasts in response management and decision making.

Because repeated demonstrations have highlighted the accuracy and importance of surface current data to oil spill response, HF radar data are being integrated with NOAA spill response models. This will enable spill responders to predict the pathway of a spill, allowing precision in containment and clean-up. David Panzer, an oceanographer with the Minerals Management Service—now the Bureau of Ocean Energy Management—writes that surface currents "greatly enhance our ability to calculate oil spill trajectories." [1]

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Coastal recreation

HF radar technology is also useful for coastal recreational activities, and sailing—where HF radar-derived surface currents can assist with course planning—is a prime example.

Ray Huff and John Ugoretz, co-captains of the 34-foot chartered yacht the *Getaway*, plotted their course using wind forecasts and surface current web-based data products in the 61st Newport to Ensenada Yacht Race in April 2008.

"I used both wind forecast and ocean current information to help plan my route for the race. Perhaps the most important factor in our strategy was a decision on where to be at night, when the winds are the lightest," Ugoretz wrote. "Using the … HF radar-derived surface current information, we were able to average 2.5 knots of boat speed all night long. This may seem slow, but I've had years where we drifted backwards at night with no wind and a counter current."

Ugoretz used Southern California Coastal Ocean Observing System-provided wind forecasts and surface current maps to plot the team's winning route, finishing 90 minutes ahead of the number two boat in their category on corrected time. Ugoretz commented that his proposed route nearly matched that of a competitor, who had developed it using complex sailing models.

The sailors used both 48-hour wind forecasts and the near real-time surface current visualizations provided as interactive online web visualizations. This product is useful for sailing and recreation, as it gives the user an indication of dominant flow patterns that may affect their operations.

In addition to helping sailors plot their course, mariners, scuba divers, and recreational boaters can also use web-based data products to check on conditions in coastal areas.

Look Mom—No Hands!

Dynamic positioning and its effect on the mariner

by LT Paul J. Folino, P.E.
Staff Engineer, Office of Design and Engineering Standards
U.S. Coast Guard

An Industry Ripe for Innovation

Ever since the monumental discovery of oil in Titusville, Pennsylvania, in 1859 and the subsequent formation of the petroleum industry in the United States, there has been a push to find *more.*[1] This drive to locate the lifeblood of industrialization in America led to oil magnates and entrepreneurs wading into far less familiar territory—water. As long ago as the early 1900s, there are instances of drilling over water in Louisiana, California, Ohio, and Pennsylvania. These historic moments in offshore drilling proved the viability of this endeavor, but the industry as we recognize it today has roots in the Gulf of Mexico.[2]

In the early 1940s, geologist Orval Lester Brace speculated on the existence of salt-dome oil in the Gulf of Mexico. A salt-dome is a large subterranean structure which often indicates the presence of oil, and is the predominant mark of oil in the Gulf of Mexico. Validation of this crucial question came in 1947, when the experimental offshore rig, Kermac Rig No. 16, owned by Kerr-McGee, sprung oil out of sight of land. Brace, understanding the engineering feats required for drilling offshore stated, "Whether or not it will ever be economically feasible to explore these waters for the domes that must exist is a question for the future to answer."[3] With the rapid development of technology in the offshore industry and maritime sector, the answer to this question of feasibility seems obvious.

In fact, offshore technology has developed at such a rate that the 20 feet of water the Kermac rig drilled in seems trivial compared to the more than 10,000-foot water column that modern oil rigs routinely drill through today. Although there are a host of innovations that have led to oil discoveries in deeper water, one stands out among the rest as being not only essential to maintaining location in the harsh, hurricane-prone environment of the Gulf of Mexico, but also causing a complete shift in how the maritime industry operates: dynamic positioning (DP).[4]

Oil derricks drilled over water as early as the late 1800s. Photo courtesy of American Oil & Gas Historical Society.

Dynamic Positioning Theory

The same entrepreneurial spirit that marked the onset of the petroleum industry in the United States translated to the realm of marine engineering with DP. In 1961, aboard the aptly-named vessel *Eureka,* Shell engineer Howard Shatto demonstrated the first fully automated vessel positioning system.[5] Though rudimentary compared to today's DP systems, this instance proved the concept and set a baseline for further innovation.

Academics in the field may argue semantics on what DP actually is, but many agree on what it is not—a single piece of equipment. Rather, DP is the integration of multiple components and subsystems, all controlled via computers and processors using mathematical modeling, to achieve the overall function of maintaining consistent and reliable position-keeping.[6] To do this requires control of position and heading of the vessel, or rather controlling sway and surge in linear motion, and yaw in rotational motion.

Because the DP system controls heading and position, input is therefore received from gyrocompasses and position reference systems (PRS), respectively. Gyrocompasses are self-explanatory, and the number of them varies with the DP class, but PRS encompass a much more diverse set of components and instruments used to maintain position with surgical accuracy. Various methods are used to maintain position on the vessel. An in-depth analysis of each would be exhaustive, but PRS generally can be broken down into:[7]

- satellite-based navigation systems, like GPS;
- laser-based positioning systems, which receive distance and bearing information from a reflective target;
- hydroacoustic systems, which depend on transponders on the seabed to relay location information to the vessel;
- microwave-based systems, which depend on transceivers and antennas on both the vessel and platform to determine range and bearing of the vessel;
- taut-wire systems, which control position based on the angle formed by a continuously tensioned wire attached to a submerged weight over the side of the vessel.

To ensure that the mathematical model is reflective of the sea state the vessel is in, there are also components such as inertial motion sensors and wind sensors that provide real-time data on the vessel's attitude in roll, pitch, and heave, as well as any wind loads the vessel encounters. Additionally, there are other sensors, like tension sensors for a pipe-laying vessel that can be outfitted on the vessel to determine mission-specific external forces the vessel experiences during operations.

All data is input into the model, which sends propulsion commands to the vessel's thrusters to maintain heading and position while counteracting the environmental forces. This communication throughout the various DP system components is enabled by sophisticated power and control systems that, depending on the redundancy level of the vessel, have detailed requirements for location and number of subsystems. In fact, there are redundancy requirements for all DP system components, but the specific design of the DP system usually depends on the mission of the vessel.

Redundancy, Redundancy, Redundancy

Redundancy is the "existence of more than one means of performing a required function," and it lies at the core of DP. Regarding DP operations, redundancy addresses the risk associated with mission operations, which could endanger life or adversely impact the environment. In the United States, these levels of DP redundancy, called equipment classes, are divided into DP-1, DP-2, and DP-3, and characterize the system from least to most redundant, respectively. The basis of delineating between different DP systems is called the "worst-case failure design intent," and it describes the minimum amount of equipment and components necessary to still maintain position following a worst-case failure.[8]

The incorporation of duplicate and triplicate redundant systems in DP is essential to ensuring that safety-critical operations, like drilling, can be accomplished without risk of a loss of position and a subsequent emergency disconnect sequence—or worse. However, with more automation, the mariner is given less tasking with "driving" the vessel and more tasking with ensuring that the DP system and its numerous components are functioning properly. This, by no means, discredits the dynamic positioning officer (DPO). There is unimaginable responsibility that mariners must accept in ensuring not only that the DP system is maintaining position, but that they know what to do if a component stops working or the vessel is driving off position.

Regardless of the tasking, the abundance of DP-capable vessels in the Gulf of Mexico plays a pivotal role in our Outer Continental Shelf activities, and surely illustrates the paradigm shift in the offshore industry from the traditional ship-driver to the human-machine interface.

Man or Machine?

Following on the heels of the *Deepwater Horizon* oil spill, former Coast Guard Commandant Admiral Thad Allen, testified in front of the Senate Committee on Commerce, Science, and Technology on the need for standards governing dynamic positioning reliability. He testified that "… technology has probably gotten out farther ahead of regulations."[9]

Though at times frustrating for regulators, this is the hard truth about the acceleration of technology, compared to the rulemaking process. While the seemingly slow pace of regulatory development can be trying, at times, the focus is not necessarily on enacting rules that keep up-to-date with regards to the technology. It is not a winnable fight trying to get in front of, or even to stay abreast of, technological development. Rather, the true test is in writing regulations that ensure operators can do their jobs effectively, particularly with rapid changes in technology.

On November 28, 2014, the U.S. Coast Guard published a notice of proposed rulemaking (NPRM) outlining the requirements for MODUs and Other Vessels Conducting Outer Continental Shelf Activities with Dynamic Positioning Systems. The highly anticipated "DP rule" was meant to provide regulations that align with current technology and operations. While the NPRM does go into the basic design of DP systems and automation, a vast majority of the regulation is aimed at the operation, training, manning, and watchkeeping components of DP systems to align the competence required in light of the emerging technologies.

It is in this pivotal human element domain where the core of the DP rule lies. In the ever-changing and continuously evolving maritime industry, where tasks, both menial and complex, are increasingly delegated to computer systems, how do we ensure the mariner is prepared to respond appropriately when required?

The Coast Guard and industry both play a crucial role in ensuring safe DP operations aboard drilling rigs and vessels. U.S. Coast Guard photo by Petty Officer Dustin R. Williams.

Last Line of Defense

Advances in technologies allow numerous industries to automate a growing number of functions previously handled by humans. While it would seem that engineering humans out of the system would decrease errors, this is unfortunately not the case. Automation provides consistent and predictable performance, but lacks the judgment and adaptability that humans possess to respond in unpredictable environments.

Even though humans are extraordinarily adaptable as a system component, they are still fallible. Therefore, automation does not eliminate human tasks and associated opportunities for error; rather, it changes them. The ship driver in today's DP-centric offshore industry needs to possess an abundance of knowledge as it relates to troubleshooting and contingency plans, in addition to the arduous task of understanding ship behaviors with different thruster and rudder commands. Essentially, the DPO needs to possess the technical acumen of an engineer in addition to their daily role of driving the ship.

This is a drastic shift from the previous dichotomy between "deckies" and engineers. The high stakes of drilling in increasingly deeper water has significantly reduced the response time that a deck officer has in solving technical problems that were typically the role of an engineer. Historically, a casualty in the navigation or propulsion system would likely result in lock-out and tag-out, and an eventual resolution to the noncompliant condition of the vessel, likely at anchor. Now, any slight deviation from position can cause excessive stresses in the drill riser, which is connecting the vessel or platform to the seabed. Therefore, the DPO fills the crucial role of making split-second decisions that affect the safety of the vessel or platform when all redundancy groups have been compromised.

To say that DPOs serve only to provide the human touch once all DP components and subsystems have failed truly diminishes their complex role. The DPO must have an intimate understanding of DP systems, be well-trained, and think quickly under pressure to note any change in status of the DP system and apply preventative measures to ensure the system does not progressively degrade.

Bolstering the Last Line of Defense

With the DP rule now in the final rule stage, there are provisions in place to facilitate safe DP operations through design, training, manning, and watchkeeping components. In promulgating these regulations across the mission-diverse offshore industry, one thing is apparent: The devotion of all sections of the offshore industry to promoting safe, incident-free DP operations. The efforts of industry in collaborating with and advising the Coast Guard on the nuanced, operational aspects of DP systems have only made for more regulatory awareness regarding the DP Rule.

While the induction of automated systems, such as DP, has certainly been a game changer regarding the roles of mariners aboard vessels, one thing that has not changed is the relationship between the Coast Guard and industry in ensuring a safe and thriving marine transportation system.

About the author:

LT Paul Folino reported to Sector New York as a marine inspector in May 2010. After qualifying in the foreign and domestic branches, he attended graduate school to study naval architecture and mechanical engineering under the Marine Safety Engineering program. In June 2015, LT Folino reported to the Office of Design and Engineering Standards at Coast Guard Headquarters, where he currently drafts domestic and international regulations for dynamic positioning systems.

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Why We Should Care

The insurance market and changing maritime industry risks

by Mr. Michael Kingston, Esp.
Legal Advisor to the London Insurance Market
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Two of the largest and most high-profile disasters in recent years occurred within a relatively short time: *Deepwater Horizon* exploded and sank in the Gulf of Mexico in April 2010, and the *Costa Concordia* ran aground in the Mediterranean in January 2012.

The *Costa Concordia* disaster cost the insurance industry $2 billion. Both accidents resulted in reviews by Lloyd's of London, which focused on best practice standards and regulatory issues surrounding the incidents. The reviews also focused on technical issues, like the failure to cap the Macondo oil well in the case of *Deepwater Horizon* and the *Costa Concordia*'s increased vessel size.

Meanwhile, ice was melting at a record rate in the Arctic, resulting in increased activity in the oil industry there, as well as an increase in transits of the northern routes. This coincided with the finalization of the International Maritime Organization (IMO)'s International Code for Ships Operating in Polar Waters, or the Polar Code, implemented in January 2017, by way of hugely significant amendments to the three cornerstone conventions of the IMO:

- the International Convention for the Safety of Life at Sea (SOLAS);
- the International Convention for the Prevention of Pollution (MARPOL); and
- the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW).

The *Deepwater Horizon* and *Costa Concordia* disasters were "game changers" from an insurance industry perspective, and the industry's approach could also be referred to as game-changing in terms of its contribution to the international regulatory process and "best practice" standard practices work. This work is ongoing, and involves significant international collaboration.

The January 13, 2012, *Costa Concordia* shipwreck near the coast of Giglio Island, Italy. Photo by dvoevnore / Shutterstock.com.

Lloyd's Approach to Risk Analysis

In its analysis of risk, the insurance industry employs scientists, mathematicians, and actuaries with various specialties, depending on the type of markets in which the insurers specialize. As an insurance market, Lloyd's of London supports many businesses across the world in all types of specialized sectors, with a heavy emphasis on new and emerging sectors. The market has a long tradition of supporting specialist maritime and energy operations across the world.

The insurance industry focuses on trying to prevent accidents and pollution, but also to create certainty in liability regimes when incidents do occur. To do this, Lloyd's emerging risk team is dedicated to looking at new issues of concern that arise in the insurance world, including investigating new frontiers and conducting reviews of incidents to ascertain

The *Q4000* and the *Discoverer Enterprise* flare off gas at the site of drilling operations at the *Deepwater Horizon* response site at night on July 8, 2010. U.S. Coast Guard photo by Petty Officer Matthew Belson.

why they occurred. The team runs a competition each year called the Lloyd's Science of Risk Awards and frequently prepares reports working with leading industry experts in an attempt to reduce the parameters of risk. The importance insurers place on research cannot be overemphasized.

Lloyd's *Deepwater Horizon* Review

The Macondo oil spill, also known as the *Deepwater Horizon* disaster, occurred on April 20, 2010, killing 11 people and spilling 4.9 million barrels' worth of oil into the Gulf of Mexico. Following the incident, Lloyd's of London commissioned the report "Drilling in extreme environments: Challenges and implications for the energy insurance industry," which was unveiled at a conference in London in September 2011. The conference focused on a hypothetical *Deepwater Horizon* scenario in other jurisdictions across the world.

The conference was attended by over 450 insurance and marine delegates, which was symptomatic of the industry's concern following this spill. Though the Lloyd's market was not directly liable for the oil pollution—BP was self-insured—given the repercussions in the U.S., including the potential record criminal fines and liability, there was cause for serious concern. It begged the question: Had Lloyd's insured a liable party to such an incident, could it have wiped out the Lloyd's insurance market?

It was clear that the industry was not prepared for such an oil spill liability incident in terms of financial capability, nor was it prepared in terms of domestic and regulatory regimes, both to prevent such an incident or deal with the liability following such an incident.

OSPRAG Capping Kit

Of immediate importance following the disaster was the technical review which considered what solutions could be put in place in the event of a repeat of Macondo, where, among other failures, the blow-out preventer failed. Thus, in the United Kingdom, Oil and Gas UK—the organization representing the oil and gas industry—immediately set up the Oil Spill Prevention and Response Advisory Group (OSPRAG) to ensure that any lessons learned from Macondo would lead to changes in operating practices in the North Sea.

OSPRAG, established in 2010, included senior representatives from all sides of the industry including regulators, trade unions, the Maritime & Coastguard Agency, and the Secretary of State's Representative for Maritime Salvage and Intervention. Additionally, a representative from the EU Energy Commission attended as an observer.

Within a short space of time, OSPRAG designed and constructed a well-capping device known as the OSPRAG

Capping Kit. The device was revealed on September 6, 2011. It was a relatively simple solution that might have prevented the disaster in the Gulf of Mexico, and saved the operator from a huge liability. It was considered a fundamental failure of industry that no such device previously existed.

Financial Capability

It is important to point out that, had BP not had such a strong balance sheet, the citizens of the United States would have had to pick up the bill for *Deepwater Horizon.* With this in mind, the review into the Macondo oil spill also focused on financial responsibility levels for oil pollution liability, resulting in a revision to the requirement for demonstration of financial responsibility by companies wishing to obtain a license to drill in the UK North Sea. The old limit of $250 million was no longer sufficient, given what happened in the Gulf of Mexico and the enormous liability incurred.

Companies wishing to carry out activities now need to show financial responsibility to a level determined by the geographical location of the well in question, with varying levels of finance required from $250 million up to $750 million, depending on the drilling area. This may include a parental company guarantee or an insurance product.

International Regulatory Review

Despite the revision increasing financial responsibility levels in the United Kingdom, it was also important for the insurance industry to consider the implications of Mocando-type spills around the world, and the international liability regime. It was immediately clear that the implications of the *Deepwater Horizon* disaster for the oil, gas, and other high-risk industries would be both global and broad in scope. The scale of the international media coverage and political intervention that followed was unprecedented, and it pushed the issue of safety in the oil and gas industry higher up the political agenda.

A shipping container washed ashore October 13, 2011, after the M/V *Rena* wrecked on the Astrolabe Reef off the coast of Tuaranga, New Zealand, eight days earlier. Photo by Brian S/Shutterstock.com.

The reviews clearly demonstrated that there was no universally agreed-upon method for dealing with pollution from fixed structures, and that liability for such incidents was very much down to individual jurisdictions. It is therefore not surprising when international conventions like the 40-year-old draft of The Convention on Civil Liability for Oil Pollution Damage Resulting from Exploration for and Exploitation of Seabed Mineral Resources fail to be ratified.

Prevention is Better than Cure

Dealing with liability after an incident has happened is one thing, but the insurance industry could plainly see that it's more important to prevent such an incident in the first place. It was clear from the reviews that human error, safety culture, risk assessment, communication, and control of contractors are always highlighted as problems; the root causes of accidents are usually the same; and regulatory regimes across the globe are fundamentally different—and sometimes deeply flawed. In the absence of a global convention, the regulations in drilling operations are left to the individual jurisdiction.

In the United States, the January 2011 publication of the U.S. report and recommendations by the national commission on the disaster, with internal reports by BP and Transocean, shed considerable light on the facts and circumstances which led to the fire and explosion. In terms of safety management, the conclusion of the national commission was damning, saying "… this disaster was almost the inevitable result of years of industry and government complacency and lack of attention to safety."

It was clear that fundamental changes would be required. This was later confirmed in the U.S. Coast Guard's report, and it resulted in the decoupling of the regulator and the health and safety executive, where, it stated, there was a clear conflict of interest.

Lloyd's Removal of Wreck Report

While the insurance industry was digesting the reviews following *Deepwater Horizon,* another issue was rapidly escalating—the cost of removing wrecks.

No sooner had the conference regarding *Deepwater Horizon* finished than the M/V *Rena* ran aground on the Astrolabe Reef off New Zealand in October 2011. Its cargo included 1,368 containers—of which eight contained hazardous materials—as well as 1,700 tons of heavy fuel oil and 200 tons of marine diesel oil. The nature of the cargo, coupled with the pristine environment, made it particularly difficult to remove the cargo and the vessel, racking up mounting costs.

Lloyd's decided to commission a report into the rising cost of removing wrecks, but little did it know what was around the corner. On January 13, 2012, Captain Francesco Schettino took the *Costa Concordia* too close to Giglio Island off the Italian coast. The catastrophic results brought

concerns regarding the level of liability surrounding the *Rena* into perspective, and allowed the *Costa Concordia* to insert herself into history as the center-page case study in the 2013 Lloyd's report "The Challenges and implications of removing shipwrecks in the 21st Century."

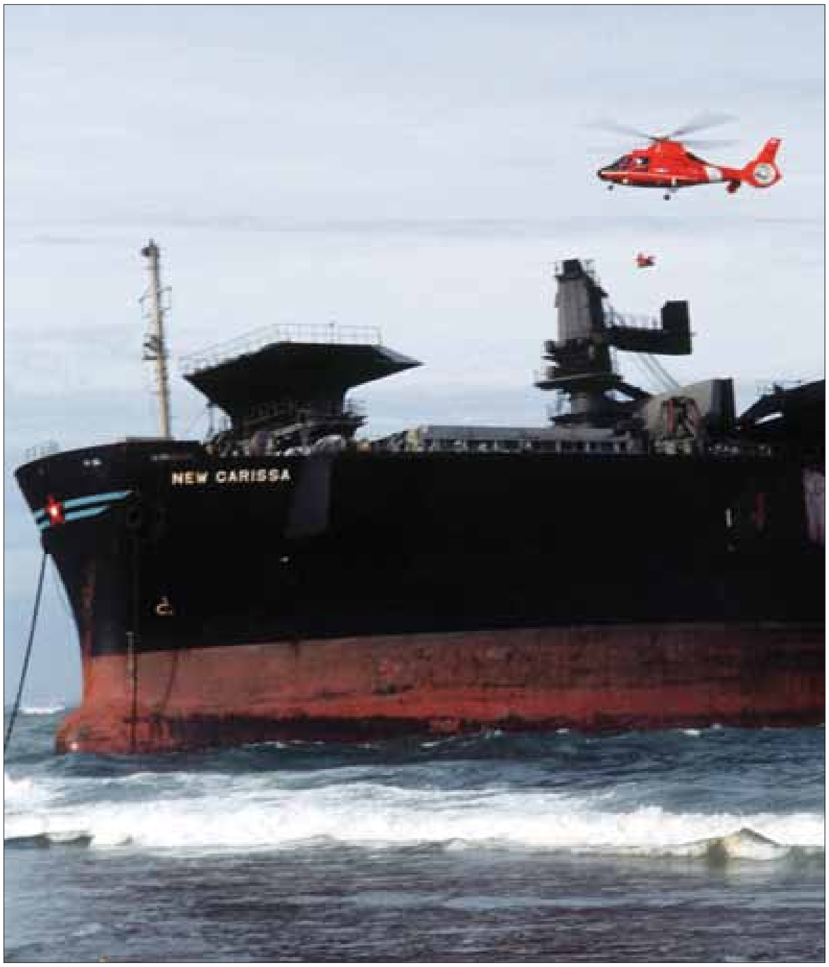
The report found there are about 1,000 casualties each year, but successful intervention and salvage meant only about 100 become actual or constructive total losses rendering the casualty a wreck.

Considering the Environment in Wreckage Removal

Where the ship or cargo presents a hazard to shipping or the environment, it is likely the coastal state concerned will order its removal. The responsibility for removal will fall on the ship owner's liability insurers; first their Protection and Indemnity (P&I) Club, then the International Group (IG), then the IG's self-insured captive, and then the re-insurance market when the IG of P&I Club's threshold of $70 million and then their captive insurance level is crossed.

The cost of removal in several high-profile cases prior to and during the report had been far more than $70 million. Many wreck removals are straightforward for the specialist experts involved, but some are more complex. The International Group's large casualty working group found the rising costs are the result of the coastal state authorities' increased requirements, which focus on mitigating environmental risk. The concern is not just in relation to matters concerning where the wreck lies, but also in regards to pollution and requirements to recycle the removed wreck. It is no longer appropriate to sink the bow, mid, or stern section of a ship 40 miles off the coast. In many instances, she must be brought ashore and recycled, as was the *Costa Concordia*.

(Top) The stabilized wreck of the *Costa Concordia* enters the port pushed by tugboats. (Right) Once in dry dock at the San Giorgio shipyard, the dismantling of the *Costa Concordia* began. Upper decks were removed until only the hull remained. Photos by Riccardo Arata / Shutterstock.com.



(Top) The Coast Guard helps avert environmental catastrophe after the bulk carrier *New Carissa* ran aground February 4, 1999, one mile north of Coos Bay, Oregon, and began leaking oil. (Bottom) The ship's remaining fuel was intentionally ignited to help prevent nearly 400,000 gallons of oil from reaching the shoreline. U.S. Coast Guard photos by Petty Officer Brandon Brewer.

This year marks the 50th anniversary of the sinking of the oil tanker *Torry Canyon* off the south coast of England, when the solution to removing the wreck and cargo was to call in the UK Royal Air Force and bomb the wreck. Similarly, when the M/V *New Carissa* ran aground on a beach near Coos Bay, Oregon, during a storm in February 1999, the solution was to torpedo part of the ship once towed offshore. It is highly unlikely that environmental concerns would allow for such solutions, giving rise to increasing wreck removal costs.

Human Error

The report also looked at the cause of casualties, a key concern for the industry. Lloyd's Agency figures indicate that globally, groundings accounted for 45 percent of cases; mechanical breakdown, 23 percent; fire, 8 percent; and collision, 6 percent.

The report highlighted human error, at sea or in the office, as the cause for up to 80 percent of incidents. This can include a variety of issues, from inattention on the part of the lookout, which can lead to collision or grounding, to lack of professionalism. Other issues include misdeclared cargo onshore and cost-cutting measures in relation to vessel maintenance or supply of equipment.

The *Costa Concordia* really highlighted the fact that, had modern technology been employed to prevent human error, there would have been no casualty in the first place. It was a timely reminder that, while it is important to recognize opportunity, that industry must identify and address the risks involved for such opportunity to be maximized in a sustainable way.

Increased Vessel Size and Lack of Equipment

The report also highlighted that one of the main factors involved in rising costs is the scant availability of suitable heavy lifting gear. Much of what exists is chartered to the offshore sector and concentrated in key locations like Western Europe, the Gulf of Mexico, Singapore, Northeast China, and Japan. This was a key factor in the high costs for removing the *Rena* in a more remote location like New Zealand.

Additionally, wreck removal equipment has not kept pace with increasing vessel size, which is a real concern. Vessel size has increased dramatically, especially box ships, LNG carriers, passenger ships, and bulk carriers. In short, ships are designed to safely carry large amounts of cargo, but not to be easy to remove as wreckage. Most agree that, while contractors are highly capable and innovative, there are concerns about a capability gap opening between equipment and experience of the largest vessels. In this context, regarding the ships themselves, there is a school of thought that the crew could perhaps be losing the intrinsic knowledge of these vessels.

The Arctic—A New Frontier of Risk

It is all very well compiling reports and making recommendations, but it is another thing to follow through on those recommendations.

At the same time as the reviews into *Deepwater Horizon* and removals of wrecks were taking place, Lloyd's also recognized that the Arctic was an emerging frontier of risk. It was clear to all concerned that for operations to take place safely in the Arctic, in the shadow of the *Deepwater Horizon* and *Costa Concordia* disasters, much more work would need to be done to reduce risk. The insurance industry would have to step up and play its role, along with the maritime and energy industries.

At the same time that the various reports were launched and recommendations made, the IMO's draft Polar Code was being discussed in London at the IMO. However, to address the concerns raised in the various reports, the Polar Code needed to be fit for purpose. One of the key elements in the Polar Code is the requirement to have a Polar Waters Operational Manual, or PWOM. Effectively, the PWOM must demonstrate that an operator has planned for a worst-case scenario "in the conditions that may occur" during the planned voyage, or if the ship has a fundamental problem with its intended functionality.

The insurance industry, and indeed many of those working on the Polar Code, found this difficult to understand, which would have created huge problems for operationalizing the code. There was a good description of what type of ice the ship could withstand and operate in, but for preparations in advance and actual operations, there was no guidance to link the likely conditions that may be encountered in the area the ship would be intending to operate in.

Therefore, how would an operator determine operational limitations for the actual ship in question? How could you complete your Polar Waters Operational Manual without this guidance, or obtain a Polar Ship Certificate confirming the operational limitation method has been applied when there was no method to consider? Canada operated the AIRS system, and Russia, the Ice Passport System, but there was no universal system for the Arctic and Antarctic with benchmarked limitation guidelines, perhaps creating a recipe for confusion and impending disaster.

Insurance Industry Initiative

Having served as a legal advisor on Lloyd's Arctic report following its April 2012 launch in Oslo, Sweden's senior Arctic official contacted me, asking to arrange discussions regarding maritime operations with some prominent Arctic ice captains. Sweden held the chairmanship of the Arctic Council from 2011 to 2013. Introducing the ice experts to the insurance industry in London, we drafted a document of standards that went beyond regulation, the "Arctic Marine Best Practice Declaration," which we put through industry consultation.

Recognizing their opportunity following the recommendations highlighted in the various reports, the declaration was backed by the International Union of Marine Insurance, which includes Lloyd's and, importantly, the Nordic Association of Marine Insurers.

This initiative, given its backing by the world's energy and marine insurers, came to the attention of the IMO. In February 2014, at the suggestion of Transport Canada, and at the invitation of the National Science Foundation of the

Special Arctic Risks

At the same time as the reviews into *Deepwater Horizon* and removals of wrecks were taking place, Lloyd's also recognized that the Arctic was an emerging frontier of risk. Accordingly, Lloyd's commissioned another report, "An Arctic Opening Opportunity and Risk in the High North," which was launched in Oslo in April 2012. In summary, the report recognized that:

- **There are significant knowledge gaps.**
  - **Charting and ice data are obviously issues for mariners.**
- **Environmental consequences of disasters are likely to be worse than in other regions.**
  - **In the absence of knowledge, incidents will occur. The potential environmental consequences, difficulty, and cost of clean-up may be significantly greater with implications for governments, businesses, and the insurance industry. Transborder risks, covering several jurisdictions, add further complications.**
- **Risk Management is fundamental.**
  - **Companies operating in the Arctic require robust risk management frameworks, processes that adopt best practices and contain worst-case scenarios, crisis response plans, and full-scale exercises.**
- **Continued development of governance frameworks, with reinforcements, where possible, is necessary.**
  - **There are major differences between regulatory regimes, standards, and governance capacity across the Arctic states. The IMO's Polar Code is one major step forward in filling this gap, but the code cannot accomplish it entirely on its own.**

United States as well as the European Commission, I presented at International Maritime Organization Headquarters on the operationalizing of the Polar Code and some of the concerns of the insurance industry at the time. This ultimately resulted in the inclusion of the Polar Operational Limitation Assessment Risk Indexing System (POLARIS) in the Polar Code.

Concerns for Vessels Operating above Latitude 70 Degrees N:

- **Extreme cold can cause engine problems and make it difficult or impossible for equipment to work.**
- **There is reduced coverage by navigational aids such as GPS.**
- **Inaccurate charts and magnetic compasses are unreliable in such high latitudes.**
- **There is restricted visibility up to 90 percent of the time.**
- **Inadequate weather reports and violent storms can occur at any time.**
- **Salvage facilities are almost nonexistent.**

"Bridging the Arctic marine risk gap—The need for a cross Arctic Ice Regime—linking ice conditions to ice class requirements," a March 2014 conference in London, was intrinsic to the development of POLARIS. It brought together the insurance market and ice experts from across the Arctic and Antarctic, including the four masters of the Swedish Icebreaker *Oden*. Acknowledging that creation of regulation is one thing and enforcement is another, strong industry recommendations were prepared and sent to the Arctic Council for the creation of a forum for best practice to achieve this.[1]

The idea of a forum on best practices in the Arctic Council that would focus on inputs to determine worst-case scenarios that could occur in the PWOM under the Polar Code—including but not limited to hydrographic data, meteorology, crew training, communication, and ice charting—came to the attention of the Arctic Council's Protection of the Arctic Marine Environment (PAME) working group. Terms of reference were finalized, and the forum was included in PAME's 2017–2019 work plan during its January 2017 meeting in Copenhagen and was declared at the end of the U.S. Chairmanship of the Arctic Council in Fairbanks, Alaska in May 2017. The forum's first meeting, hosted by Lloyd's of London and Lloyd's Register, took place in London in June 2017.

As well as meeting annually in London, participants in this forum will update a web portal hosted by the PAME secretariat with best standards as they evolve so everyone will know where to get the best information on a continual basis. Each participating member will be responsible for gathering the latest developments in their area of expertise on a cross-jurisdictional basis and updating the forum.

We need to know what the best information is at any point in time, and that knowledge is currently lacking in the various decision making stages of the process by operators, flag state representatives, insurers, financiers, and port state control entities. Put simply, people do not know where to get reliable information. However, if we can do this on a practical business level, we believe it is possible to have happy insurers who will insure polar operations that are based on a sustainable approach to Arctic development so that everyone benefits. The first forum was a great success; the eight Arctic States were then requested to present the concept at the IMO in June 2018 to the World Delegations as an example of what can be done elsewhere in the world to help with the implementation of regulation in a collaborative approach. It is envisaged that the Web portal will be launched in February 2018 at the International Conference on Harmonized Implementation of the Polar Code, hosted by Finland in Helsinki.

Most importantly, a proper implementation of the Polar Code, which will only happen if done as a collective, will protect some people and the environment from disasters like the *Costa Concordia* and *Deepwater Horizon*. By helping the IMO and national governments, we perhaps might create the right behavioral atmosphere to deal with the areas outside the Polar Code. In that regard, it would be remiss of me not to congratulate and thank both the USCG and all the other U.S. agencies for their fantastic work both at the IMO and the Arctic Council. The Arctic Shipping Best Practices Information Forum is truly a great achievement by the U.S. in their 2-year Arctic Council Chairmanship. Ultimately, everywhere in the world, it is quite straightforward: Prevention is better than cure, and, as always, together we can make a difference.

About the Author:

Originally from County Cork, Ireland, Mr. Kingston is a London-based lawyer who represented the International Union of Marine Insurance at the IMO on the finalization of the Polar Code. He was the legal contributor to several reports by Lloyd's of London assessing opportunities and risks in the Arctic (2012), challenges and implications of shipwreck removal (2013), and drilling in extreme environments (2011). Mr. Kingston was named the 2014–2015 Lloyd's List Global Maritime Lawyer of the Year for his contribution to safety of life at sea in the polar regions, and he has also received a USCG Challenge Coin for his efforts to promote maritime safety by raising awareness about the IMO Polar Code.

Endnote:

1. http://polar.se/en/conference-report-sustainable-arctic-shipping-marine-operations/

Parasailing

Elevating safety standards

by CDR James T. Fogle
Former Passenger Vessel Program Manager
Office of Commercial Vessel Compliance
U.S. Coast Guard

Since the 1960s, parasailing has become a prominent recreational water sport in the U.S., gaining more popularity as years have passed. It's estimated that 3.7 million passengers participated in 2016. Presently, there are about 355 commercial parasail vessels operating nationwide, and 134 of those vessels are inspected by the Coast Guard for compliance with safety and environmental regulatory standards.[1]

Over the last decade, a series of parasailing marine casualties involving operations in questionable weather conditions and parasailing rigging exposed an urgent need for a more robust safety regime for this industry. Unfortunately, the Coast Guard still does not have regulatory authority over parasailing rigging on these vessels. This situation has motivated the Coast Guard and industry stakeholders to take action to develop a non-regulatory approach to reduce the risks associated with vessels operating with parasail riders aloft.

Voluntary ASTM Standards Development

In January 2012, the Coast Guard approached the Water Sports Industry Association (WSIA)—a proponent for education, advocacy, and leadership specifically for the parasailing industry—about the development of voluntary standards for the industry using the American Society of Testing Materials (ASTM) International's standards consensus process. A subcommittee was formally established in the fall of 2012, and after months of robust discussions and industry meetings, consensus was reached leading to the approval of a standard in April 2013: ASTM F2993, Guide for Monitoring Weather Conditions for Safe Parasail Operation.[2]

The combination of ASTM F2993 with additional standards drafted to cover equipment, operations, crew proficiency, and patron responsibility became the approved comprehensive standard F3099, Standard Practices for Parasailing, promulgated in September 2014. This standard provides guidelines and procedures for the operation, maintenance, and inspection of parasail vessels, equipment, and associated activities, including crew training and flying passengers aloft.

In his November 2016 letter to WSIA,[3] Captain Lee Boone, commanding officer of U.S. Coast Guard Activities Far East, congratulated the association for "sticking with this consensus-based standards project, and for being such a game changer for the parasailing industry!" For his part, Captain Boone was instrumental in spearheading this process while serving in his former role as chief of the Domestic Compliance Division at U.S. Coast Guard headquarters.

Different Approach Yields Improvement

The approach of the Coast Guard and the parasailing industry partnering for better safety standards compliance represented a paradigm shift from past procedures, particularly as it relates to the roles and responsibilities of the entities involved. Usually, the Coast Guard develops U.S. regulatory

Tony SuCuico, boat crewman, throws up a "shaka" sign to parasailers. U.S. Marine Corps photo by Lance Cpl. Ryan Trevino.

A parasailer aloft and enjoying the view. U.S. Coast Guard photo by CDR James T. Fogle.

standards in which the industry is required to comply while only having limited input into the process, typically during the comment period phase of a rulemaking project.

To the parasailing industry's credit, they understood the importance of using industry standards to gain consensus. From that perspective, they took the initiative to work collaboratively, using the opportunity as a way to self-regulate and to ensure their operators' commitment to make parasailing safe for all passengers. As staunch promoters of safer parasailing operations, WSIA and its membership have been very influential within the industry, communicating the effectiveness of the ASTM standards—if followed—at reducing the number and severity of parasailing-related casualties. This has been borne out by Coast Guard statistics.

Since 2013—the year coinciding with the release of the first parasailing standard, ASTM F2993—the industry has seen a remarkable reduction in the number of serious injuries and deaths associated with parasailing-related activities, as shown below. The Coast Guard attributes the improved safety record to the industry's development of the voluntary ASTM standards, and is encouraged by the industry's willingness to adhere to voluntary standards and other industry-accepted best practices to help promote safety industry-wide.

That said, while this may represent a level of success, the parasailing industry must not become complacent; rather, it must continue to advocate the use of standards while seeking areas and opportunities to improve them.

American Society of Testing Materials Standards

The American Society of Testing Materials standards are organized into five sections that address the following:

- **Weather—weather monitoring and operating limits**
- **Equipment—maintenance and inspection of equipment**
- **Operations—pre-flight procedures, flight operation parameters, and emergency procedures**
- **Crew—crew requirements, crew training, and recordkeeping**
- **Patron Responsibility—responsibilities of passengers engaging in parasailing activities**

ASTM Standards–State Impact

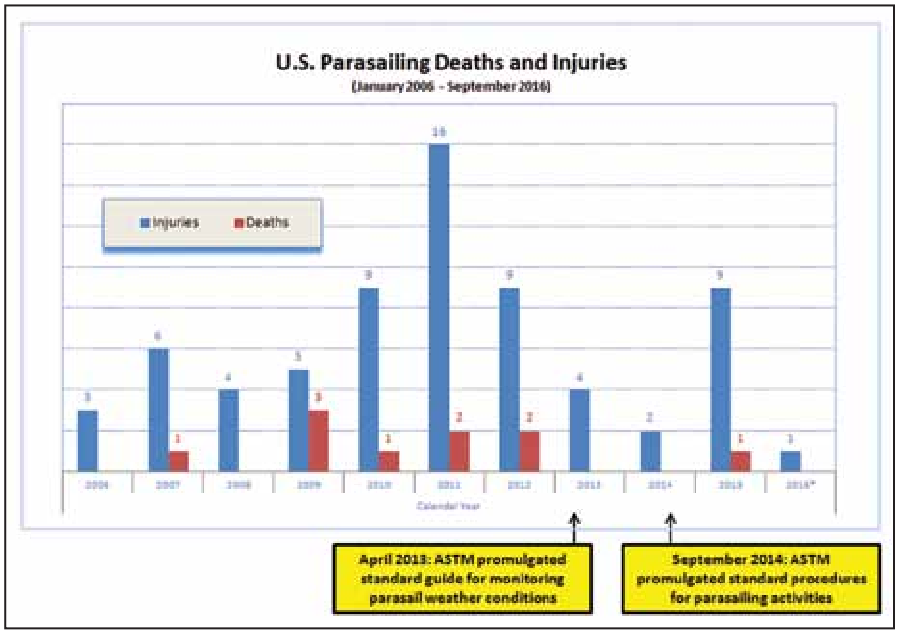
The success that the Coast Guard, WSIA, parasail industry, and ASTM International had implementing nationally-recognized standards for parasailing greatly assisted a near-decade-long effort after 2000 to get parasailing regulations enacted in Florida. Previous attempts to pass a law had failed despite substantial support within the state legislature.

Two tragic events that occurred during that time helped to turn the tide on these efforts. In 2007, teenager Amber White died in a parasailing accident, and in 2012 Kathleen Miskell fell to her death when the parasailing harness she was wearing broke while she was aloft.

The White-Miskell Act, named for those victims, was passed in Florida and took effect on October 1, 2014. The act, which used the ASTM parasail weather standard as a guide, does the following:

- Prohibits commercial parasailing unless certain equipment is present on the vessel and certain weather conditions are met, requiring that a weather log be maintained and made available for inspection
- Requires that the vessel operator have a current and valid mariner's license issued by the United States Coast Guard
- Requires that the owner of a vessel engaged in commercial parasailing obtain and maintain an insurance policy

Florida is presently the only state that has passed a parasailing law; the common-sense safety measures and standards in the voluntary ASTM standards helped make that a reality. This is clearly a signal to other states that getting this type of legislation passed is possible.



U.S. Coast Guard graphic provided by the Office of Investigations and Analysis.

NASBLA Model Act for Commercial Parasailing Requirements

The June 2014 National Transportation Safety Board's special investigation report on parasail safety made a recommendation to the National Association of State Boating Law Administrators (NASBLA) to draft a model act to assist state legislations with the development of parasail regulations. The model act would serve as a framework from which to begin the process, focusing on the unique training, operational safety, and equipment associated with parasailing.

NASBLA proceeded with this development of a model act largely because a number of its member states' agencies are responsible for regulating and enforcing laws related to parasailing in their states, and they recognized the need to establish safety standards. The basis for the model act's design was the voluntary ASTM standards, and many of its safety measures were incorporated.

In September 2015, NASBLA's enforcement and training committee adopted the NASBLA Model Act for Commercial Parasailing Requirements using knowledge and experience learned from Florida's success. This act has made it easier for other states contemplating the development of their own laws to reduce the risks associated with parasailing.

ASTM Standards–Municipal Impact

Beyond the state impact the development of the voluntary ASTM standards has had on safety within the parasailing industry, the effect can also be felt within certain localities. In 2016, the city of Gulf Shores, Alabama, revised its existing parasail code of ordinances to incorporate many of the weather-related safety measures as well as other elements of the ASTM standards, all with the goal of improving parasail safety in that community.

As a result, business owners engaged in providing parasail rides are required, as a condition of operation, to comply with all requirements. If they do not, they will face potential enforcement action.

By codifying industry-accepted best practices found in the ASTM standards into municipal code, it is now mandatory for Gulf Shores parasail operators to adhere to those safety measures, enhancing safety for parasail riders, by extension.

Improved Cooperation

With the improvement in parasail safety, there has been increased cooperation between federal, state, and local law enforcement agencies along with insurers providing policies to parasail operators. The Coast Guard has seen instances where insurance coverage was either suspended or not renewed until such time as the operator was able to rectify safety issues related to parasail operations. Noting the priority placed on passenger safety as the primary consideration, insurance providers notified law enforcement officials of such lapses in coverage to help ensure that those vessels would not be allowed to operate.

The development of the voluntary ASTM standards definitively represents a clear line of demarcation where a maritime industry—like parasailing—has successfully changed its priorities for the safety of its customers. Even better, it has established a new safety culture, producing significant results and far-reaching impact. Considering how it has influenced the development of similar parasailing safety requirements across this nation, the effects of the ASTM standards for parasailing safety clearly exemplify what it means to be a "game changer."

About the author:

CDR James T. Fogle has served in the U.S. Coast Guard for nearly 19 years. He has served in many capacities, most recently as the Coast Guard's passenger vessel program manager, responsible for oversight of the more than 6,000 U.S.-flagged commercial vessels operating worldwide.

Endnotes:

1. U.S. Coast Guard Office of Investigations and Analysis
2. G.L. Boone; Nov. 15, 2016; Letter Addressed to the Water Sports Industry Association (WSIA); retrieved from www.wsia.net/wsia-recognized-game-changer-parasail-safety/
3. Ibid.

Subchapter M— Towing Vessel Regulations

A new approach to ensuring compliance

by LCDR William A. Nabach
Office of Operating and Environmental Standards
U.S. Coast Guard Headquarters

When the Inspection of Towing Vessels final rule—46 Code of Federal Regulations, Subchapter M—was published in the Federal Register on June 20, 2016, it represented a major shift from the Coast Guard's historical approach to regulating commercial vessel operations. Typically, domestic regulations are prescriptive in nature, and compliance is proven through Coast Guard inspections for certification every five years with annual Coast Guard re-inspections. However, in the towing vessel regulations, vessel owners and operators are presented with two very different options for verifying compliance.

As Captain Jennifer Williams, chief of the Office of Commercial Vessel Compliance, wrote in her September 2016 Maritime Commons blog entry:

What is unique about these regulations is that industry is given a choice to either implement a Towing Safety Management System (TSMS) or choose to request the Coast Guard to conduct their inspections. A fully implemented TSMS establishes a comprehensive quality control system throughout the company which increases the safety and efficiency of all towing vessel operations. Across the maritime industry, vessel operators have told the Coast Guard that a proper TSMS increases safety while cutting overall operating costs. A proper TSMS will reduce accidents, equipment failures, and [undue] delays. Accordingly, the Coast Guard looks forward to using all the advantages of a fully implemented TSMS while working with the towing industry to fully implement these new regulations.[1]

Marine Inspectors from Marine Safety Unit Portland conduct a field dry dock examination to educate and train the towing vessel community on new regulatory standards that will come into force in the summer of 2018. U.S. Coast Guard photo

As these regulations are phased in, towing vessel operators may choose the option that best suits their needs. This is truly a new approach to ensuring compliance.

Regulatory Background

In the 2004 Coast Guard Authorization Act, Congress added towing vessels to the list of vessels subject to inspection under 46 United State Code 3301. Accordingly, the Coast Guard drafted new regulations for the inspection of towing vessels. After publishing a request for comment in the Federal Register,[2] holding public meetings, analyzing the work with the Towing Safety Advisory Committee, and reviewing a contractor's industry analysis, the Notice of Proposed Rulemaking (NPRM) was published in the Federal Register on August 11, 2011.[3] The NPRM's comment period, as well as the four public meetings held after its publication, generated more than 3,000 comments that were addressed during the drafting of the final rule published in June 2016.

Both the final rule and the NPRM contained the option for owners or operators to choose between the traditional Coast Guard inspections, or a TSMS option using a program of surveys conducted by either a third-party organization (TPO) or surveyors from within the towing company. For the TSMS option, the surveyor may also be a surveyor contracted by the company. Regardless of the surveyor, all surveys are reviewed during TPO audits under the TSMS.

This allowance within Subchapter M permits an unprecedented amount of flexibility for the towing industry in scheduling audits, surveys, and drydock examinations required for receiving and maintaining a Coast Guard Certificate of Inspection. This flexibility will be key to the success of Subchapter M's implementation over the next five years, and these TPOs will be instrumental in augmenting the Coast Guard's inspection capabilities on a fleet of more than 5,500 towing vessels.

U.S. Coast Guard Sector San Francisco, San Francisco Bar Pilots, local tug workgroup members, and CMA-CGM evaluate the capability of local tugboats to tow an ultra-large container vessel in the San Francisco Bay as part of an emergency towing operations preparedness drill. U.S. Coast Guard photo by Petty Officer Loumania Stewart.

The compliance will be based on adherence to a safety management system (SMS) that is tailored to the size and complexity of the towing company, its vessels, and their operations. These SMSs will be approved by TPOs.

Third-Party Organizations

Of course, the TPOs themselves need to be approved first. In order to do work as a TPO under Subchapter M, organizations must apply to the Coast Guard's Towing Vessel National Center of Expertise (TVNCOE) and be approved to conduct audit and/or survey processes on behalf of the Coast Guard for the towing vessels of companies choosing the towing safety management system option.

There is one notable exception: Recognized and authorized classification societies that have already been vetted and approved by the Coast Guard under separate regulations do not need any further approval in order to act as TPOs under Subchapter M. The TVNCOE, which has been tasked with the oversight of these organizations and their work, maintains the following information at their website:[4]

- current list of approved TPOs
- the most current guidance for applying for TPO status
- information on expectations and responsibilities of TPOs, once approved

Learn more about third-party organizations (TPOs): www.dco.uscg.mil/Portals/9/TVNCOE/Documents/SubMFAQs/Part139.pdf

TPO surveyors, or internal surveyors for those companies choosing that program, will take over the role of Coast Guard marine inspectors for the purpose of vessel surveys. The exception to this is the inspection for the purpose of issuing the initial or 5-year renewal Certificate of Inspection (COI), which will remain a Coast Guard inspector function.

As mentioned earlier, a fully implemented towing safety management system includes a comprehensive quality control system. Consequently, the Coast Guard COI process for TSMS vessels should take significantly less time and effort. This benefits both the towing company and the Coast Guard.

Under the TSMS option, the TPOs will be responsible for reviewing the towing company's safety management system against the objectives, functional requirements, and elements of the TSMS as listed in Subchapter M, and accepting the system, once found to be complete. TPOs will then be required to audit the implementation and adherence to the company's TSMS processes, procedures, and recordkeeping requirements on both the management side as well as on any vessels the company may identify as being fully compliant.

The next step is for the TPO to issue the towing company a TSMS certificate, valid for up to five years. The TSMS certificate must be obtained at least six months prior to seeking a COI for any vessel under the TSMS. The TPO will conduct a vessel audit of each towing vessel under the company's TSMS prior to the issuance of the COI, although newly acquired vessels are granted up to six months of operation after the issuance of the initial COI in order to ensure full implementation of the system prior to vessel audits.

Audit results are kept on file for five years. The TPO also submits them to the Coast Guard. The management audit results are submitted to the TVNCOE and vessel audit results are submitted to the cognizant Officer in Charge, Marine Inspection for use as objective evidence of compliance with Subchapter M. These audits provide a chance for the Coast Guard to conduct oversight of the survey program chosen by the towing company.

These TPOs must also be governed by quality management principles, and the third-party organizations' internal policies, internal procedures, individual auditors, and/or individual surveyors shall also meet the criteria listed in Subchapter M.

Flexibility

As discussed earlier, a key consideration in creating this TSMS compliance option using TPOs was to provide the industry with a considerable amount of flexibility when compared to the Coast Guard inspection option. The scheduling flexibility could be a significant financial consideration that companies need to weigh when deciding which compliance option works best for their business.

For vessels choosing the Coast Guard option, the Coast Guard has strict requirements on scheduling inspections, with substantial lead time required in order to ensure the availability of properly trained and qualified personnel. There may be instances where the vessel might be restricted from operating until a Coast Guard inspector is available either to start an inspection or to return to clear outstanding deficiencies, regardless of severity.

Under the TSMS option, the scheduling of surveys and audits is determined by the company. For example, if a company were to choose the internal survey program, they could carry out the required survey activities over the course of one year. For the external survey program, the TPO could be scheduled at the convenience of the company so as to minimize the disruption to vessel operations.

Other seemingly minor allowances within the rule could also mean additional cost and time savings for the industry. One example is "a permit to proceed." When a vessel is operating outside of its COI due to the need to proceed to another port or place for repairs to the vessel, the Coast Guard has historically been very involved in approving the voyage particulars, normally visiting the vessel to ensure its fitness for the intended voyage.

Under the TSMS option, the Subchapter M regulations allow for a more streamlined approach, with the caveat being that the TSMS for the vessel must adequately address the situation in question. The Coast Guard would still be notified prior to the voyage's start, but the amount of Coast Guard involvement would be significantly reduced. As part of the oversight of this process, the TPO may need to attend a vessel to conduct the examination of the damage prior to the voyage. However, as discussed above, this can be more readily accomplished using a service that is being contracted and paid for.

Looking Forward

As towing companies with fleets of existing towing vessels continue to prepare for the start of the first cycle of Coast Guard inspections for initial COI issuance in the summer of 2018, there may still be quite a few questions to address regarding this new inspection program. This transition from "uninspected" to "inspected" status for more than 5,500 existing towing vessels over four short years is a significant departure from historical operations for both the industry and the Coast Guard.

As noted here, the approach in presenting two different inspection options in these regulations is very unique. In light of this, all parties with a stake in the success of this endeavor—the TPO, the towing companies, the Coast Guard, and vessel crews—are encouraged to share concerns and best practices as these new regulations are phased in.

In this spirit, the Coast Guard has published frequently asked questions and corresponding answers on the TVNCOE website.[5] This list of FAQs is an excellent source for additional information about the towing vessel regulations. The Coast Guard will update this list as questions are submitted and answered. Questions are always welcome and may be submitted to the Coast Guard at AskSubM@uscg.mil.

Working together, this game-changing approach to inspections for the towing vessel industry will be successful.

Have questions about Subchapter M? Email them to the Coast Guard at AskSubM@uscg.mil

About the author:

LCDR William A. Nabach is a graduate of the U.S. Merchant Marine Academy and has served the U.S. Coast Guard's prevention/marine safety field for 19 years. He has earned master's degrees in mechanical engineering and education and has also been awarded two Coast Guard Achievement Medals as well as one Coast Guard Commendation Medal.

Endnotes:

1. http://mariners.coastguard.dodlive.mil/2016/09/02/subchapter-m-updated-faqs-towing-vessels/
2. 69 FR 78471
3. 76 FR 49976
4. Towing Vessel National Center of Expertise website www.dco.uscg.mil/tvncoe/
5. Inspected towing vessel FAQs: www.dco.uscg.mil/Our-Organization/Assistant-Commandant-for-Prevention-Policy-CG-5P/Traveling-Inspector-Staff-CG-5P-TI/Towing-Vessel-National-Center-of-Expertise/SubMFAQs/

A Future With Autonomous Ships

by Mr. Andreas Nordseth
Director General
Danish Maritime Authority

Ships with a higher degree of automation than exist today, perhaps controlled by a shore-based master, are a scenario of the future. Though, they may not be as far off as you might think. In any case, while this is possible, many steps are needed before completely autonomous ships become a reality.

Autonomous ships on the high seas will probably not come about in the immediate future, but we are not far from having autonomous ships in national and inland waters, where voyages are typically point-to-point, or more specialized.

When it comes to controlling and managing ships, the sea-land interaction has changed over the last few years due to increased ship-to-ship and ship-to-shore communication and connectivity.

Automation of work processes will continue to change in coming years, and maybe the greatest potential for growth in this area will be in harbor operations. Autonomous tugs

A tug sails through Danish waters. Photos by Lars Schmidt.

or workboats working together with manned vessels might help increase safety and strengthen efficiency. We might also see similar trends in the offshore wind energy and aquaculture sectors in the near future.

Connectivity and Data as Drivers

Autonomous ships are not a new vision. What is new, however, is that the vision is getting closer to reality. In past decades, automatic systems and automation have developed almost linearly, resulting in, for example, the autopilot and unattended engine rooms.

In years to come, this development will accelerate in shipping, as it has in other sectors like agriculture and trucks, where automation and autonomous systems are being introduced faster than we would have imagined just five years ago. Perhaps we are actually at the beginning of a period with exponential growth in the use of technology. In fact, I might even go so far as to say that I think shipping is at the doorstep of a technology jump.

Enhanced connectivity at sea and the possibility of handling and processing increasingly larger quantities of information are two key drivers of automation.

Increased continuous global connectivity will be a driver for the automatic transmission of data related to ships' equipment, sensors, machinery, navigation, cargo, etc., and for the exchange of information about their status to the company, maintenance companies, and classification societies, etc.

This connectivity to sensors and an array of other technology, combined with the ability to handle and process data, will result in the same developments in shipping as we have seen in other sectors. Some would say that, in the future, all shipping companies must be technology-driven in order to survive the competition with other sectors and large global software businesses.

A ship passes Öresund Bridge, spanning the Öresund Strait between Sweden and Denmark.

Commercial Potential

Autonomous ships are not the same as unmanned ships. There are several levels of autonomy—from manual control, over the use of an autopilot and automatic radar plotting aid radar; to remote control and supervision; and finally, fully autonomous navigation. The technologies needed to make remotely controlled, autonomous ships a reality already exists, but there is a general lack of experience using these technologies in commercial shipping.

The commercial potential of autonomous ships and automated work processes is something we cannot really grasp at the moment. It will definitely create new business opportunities in the market. This may appear in the automation of ship operations, reduced or disappearing transaction costs, reduced ship operation costs, safer and more reliable ship operations, enhanced safety of navigation, and increased energy efficiency, to mention a few possibilities.

Hopefully, more autonomous shipping operations can lead to a decrease in overall costs and create safety-related benefits. But if we are to have autonomous ships in the future, it would be because it would be market-driven, commercially viable, and beneficial for ship owners. In other words, the use of new technologies needs to add value to the maritime supply chain in order to become a reality and to be applied to optimize and improve shipping operations. Automation at all levels and in all industries has the potential to minimize the risk of errors by supporting and reducing the risk of incidents, causalities, and accidents.

Impact on Jobs

Automation and autonomous ships will also change the work of seafarers who may need new competencies, take on new work routines, and experience a significant impact on their daily work at sea.

In the future, there will also be a need for competent and professional seagoing personnel in connection with the development, construction, maintenance, and supervision of operations. Investments in equipping fairways and transport routes with intelligent sensors to ensure safe maritime transport will also provide new jobs and businesses catering to the infrastructure.

Developments in technology, digitalization, and automation may move some tasks ashore or further change the interaction between shore and offshore operations. The new technology introduced to the maritime domain will require maintenance, servicing, and updating. Remote operation of hubs will require technicians, navigators, and engineers, thus creating a wide new field of professional maritime experts.

The Regulatory Framework

It will be important for the international maritime community to take the development of new technology seriously, and create goal-based, technology-neutral regulation in the future that supports the development and integration of automation into the global legislative framework of the International Maritime Organization. What we want is a specific level of safety, but also the possibility to use new technology and solutions to reach the common goal.

It is important that all stakeholders share local, national, and regional experience and studies, including technical, legal, and operational aspects of autonomous shipping as well as knowledge of ongoing research, testing, and full-scale projects to ensure the maritime world better understands the possibilities.

Research on Autonomous Vessels

The Danish Maritime Authority, together with the Technical University of Denmark, has published a pre-study on the potential for autonomous ships, as the "blue" community needs to understand what autonomous ships are all about. The pre-study shows there is great potential in developing new autonomous technology, which could significantly contribute to efficient ship operations and mitigation of risk factors that could otherwise result in accidents.

The Danish Maritime Authority

The mission of the Danish Maritime Authority is to effectively strengthen and promote safety and health on clean seas. It serves as an entity for implementing, enforcing, and monitoring the mandatory instruments relating to flag state, port state, and coastal state activities. We are the primary responsible entity.

We seek to engage in the digitization of shipping in a strategic and international context, with the aim of enhancing efficiency of shipping and bettering the maritime industry, benefiting safety, security, economic growth, and the creation of jobs in our maritime cluster.

3 Levels of Autonomy

- **System automation combined with on-board manning for decision making**
- **Automation through remote control**
- **Full automation without any human interference**

In economic terms, the gain will be reduced operating costs. As one ship owner expressed, "Every year, our ferries have a total of 40,000 port calls where each operation may last from five to 10 minutes. If these calls are optimized through technology support, there may be significant fuel consumption savings—also to the benefit of the environment."

Another major conclusion from the pre-study is the need to categorize automation levels, define them, and develop a methodology for the level of automation needed to ensure a certain "business model." In other words, economic gains and technology developments must go hand in hand.

As a next step, the Danish Maritime Authority will develop pilot projects to address a number of unresolved issues such as legal barriers, risk assessment studies, and, last but not least, financial and insurance issues that we need to learn more about.

The report is available in its entirety from the website of the Danish Maritime Authority.[1]

About the author:
Mr. Andreas Nordseth has worked for the Danish Maritime Authority for 25 years, serving as director general since 2009. Before joining the Danish Maritime Authority, he was, among other things, a teacher at the Copenhagen Nautical College, a nautical officer of the Reserve with the Danish Navy, a training officer of the Danish training ship Danmark, *and a deck officer at the East Asiatic Company.*

Endnote:

1. www.dma.dk/Documents/Publikationer/Autonome%20skibe_DTU_rapport_UK.pdf

Influences on the Robotic Hull Cleaning Market

by Brendan O'Connor
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Carolyn Lowe
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Worchester Polytechnic Institute

Robotic hull cleaner manufacturers face a variety of challenges concerning design and desired capabilities. The fundamental abilities of a hull cleaner include accessing and cleaning diverse hull features, remaining attached to an inverted hull while underwater, and preventing pollution in accordance with a variety of regional environmental regulations. Ideally, a hull-cleaning robot would quickly clean a vessel while in port, but it would be even more desirable for that robot to clean the vessel while underway, and without requiring much maintenance or energy.

In general, an ancillary system such as a hull cleaner should not add operational risk concerning safety, operations costs, or the environment. This article summarizes present objectives and desired capabilities influencing the development of hull-cleaning machines.

Hull Shapes

Displacement hulls are shaped roughly like a bathtub. They are lower in the water, and much of the volume of the ship is submerged. As ship speed increases, the same amount of the hull remains in the water. Since the entirety of the vessel stays in the water, as the speed increases, the drag increases linearly, making attaining high speeds difficult. However, the design greatly increases the amount of cargo space available, and simplifies the design.

Semi-displacement hulls form sharper curves, which causes the buoyant force to lift the front end of the vessel higher as it picks up speed. This improves the speed and reduces the drag on the vessel, but can make the vessel less stable. Semi-displacement hull forms cost valuable cargo space as a result of their shape.

Planing hulls use beveled curves to push the front end of the vessel entirely out of the water. At lower speeds, the hulls' characteristics resemble displacement hulls, allowing them to plow through water. These ships are designed to skim along the surface of the water at high speeds.[1]

Endnote:

1. Hull descriptions based on S. Khasnabis, May 3, 2016, "Choosing a hull form for ships: A naval architect's perspective," retrieved November 20, 2016, from www.marineinsight.com/naval-architecture/choosing-a-hull-form-for-ships-a-naval-architects-perspective/

Ship Design Challenges

Hull-cleaning robot design requires consideration of the diverse hull designs, sizes, and niche areas, addressing as many as possible. Alternatively, hull cleaning manufacturers can target a particular hull type or class and attempt to create a niche market for their device.

Hull Design—The design of the target hull is important when considering the performance of a hull cleaning system. Depending on weather and design requirements, vessels can have a single hull or multiple hulls. Hulls can also be classified by shape, including displacement, semi-displacement, and planing hulls.

Hull Surface Area—Along with the shape, the ship's size is an important factor in determining the performance criteria for a hull cleaner. The average surface area of commercial hulls for this article is based on a 2010 ABS Consulting report that estimated the cost of biofouling on a vessel based on its square footage. That report concluded that the cost to remove one square foot of biofouling was $0.33.[1] The following tables briefly summarize a general surface area estimate for each class of commercial vessel.

The classification of the vessel is determined by either dead weight tonnage (DWT) or twenty-foot equivalent unit (TEU). DWT is a measure of maximum weight, while a ship's TEU represents the number of 20-foot containers it can accommodate.

Table 1. Bulk Carrier Hull Size

Type	DWT	Square feet of a hull
Handy	<50,000	161,593
Panamax	50,000–80,000	212,936
Capesize	>80,000	266,884

Bulk carriers are ships specially designed to transport unpackaged bulk cargo such as grain, clay, cement, or sand.

Table 2. Tanker Hull Size

Classification	DWT	Square feet of a hull
Handy	<35,000	150,606
Handymax-Aframax	35,000–120,000	276,976
Suezmax	120,000–160,000	294,176
VLCC	160,000–320,000	259,558
ULCC	>320,000	241,333

Tankers are vessels designed to transport liquids or gases in bulk.

Table 3. Container Ship Hull Size

Type	TEU	Square feet of a hull
Feeder	<500	223,860
Feedermax	500–1000	225,267
Handy	1000–2000	128,909
Subpanamax	2000–3000	275,127
Panamax	>3000	300,048

Container ships are designed to transport cargo inside of standardized containers.

Niche Areas—Ideally, a hull-cleaning robot would be capable of cleaning without damaging features on a hull. Features are protrusions or depressions such as bulbous bows, thrusters, stern tubes, seawater inlet chests, stabilizers, and keels. These are collectively referred to as niche areas.

Bulbous bow: A sphere-like bulb at the bow of the ship that lies just under the water line. The bulbous bow disrupts the wave at the front of the vessel by creating a second flow of water that cancels out the first, allowing the boat the move with less resistance.

Thruster: An additional propulsion device that can either be built into the hull during construction, or installed later. A thruster can increase the vessel's speed or allow the vessel to change direction faster. The different types include bow thruster, azimuth thruster, and transverse thruster.

Stern tube: A long shaft that connects the vessel's engine and the propeller. This is also known as the propeller shaft.

Seawater inlet chests: A rectangular or cylindrical recess in the hull of a ship. This creates a reservoir a ship can draw raw water from for cooling shipboard operations.

Ship stabilizer: (retractable, un-retractable) A fixed fin stabilizer and bilge keels. Stabilizers function similar to wing flaps on an airplane. They are positioned on the sides of vessels below their waterlines and prevent the ship from rolling. Stabilizers add resistance at the cost of a smoother ride.

Vessel keel: A blade extruding into the water from the bottom of the vessel. It has two main functions: holding the ballast, allowing the boat to stay right side up; and preventing the boat from being blown over by the wind.

These features obstruct a hull-cleaning robot's movement and access to fouling organisms. Consequently, hull-cleaning robot manufacturers have collectively developed a wide array of approaches to address the obstacles a hull's design, size, and features pose to the successful operation of robotic hull cleaning.

An investigation into commercial robotic hull cleaners suggests that there are currently about 20 models on the market or in development.

Commercial Technology Challenges

The following are considerations of the qualities and parameters to which robotic hull cleaners may be assessed and compared. The qualities and parameters that would best suit a vessel's needs will vary widely depending on the vessel type, size, duration of its voyages and stays in port, and geographical locations that will influence the types and speed of fouling organism growth it accumulates. (See Table 4.)

This industry is new in the sense that legislation requiring hull cleaning is not widespread and does not distinguish between traditional manual cleaning, or drydock cleaning.

The robot's operating type can be distinguished by the operational level of autonomy. *Semiautonomous* means the robot handles some of its operations without user intervention, but not all. *Autonomous* means the technology requires no interaction from the user to operate. *Manual* means every command the robot executes is directly input by a user. A profile of the robot's features is also provided. The robot's capacity to filter biofouling, its method of remaining attached to the hull, and cleaning system are reported. (See Table 5.)

Regulations Challenges

The in-water cleaning of a hull can result in the release of the organisms being removed as well as chemicals within the hull's protective coating. Around the world, new regulations are in various stages of development to prevent the spread of invasive species and contaminants released from the act of hull cleaning.

The regulations are in general agreement that when fouling organisms are dislodged, the debris should be contained to prevent the spread of invasive organisms and pollutants such as heavy metals and biocides used in the hull's coating. The methods for cleaning, and to what standard, are yet to be determined by best available technology and regulatory enforcement. Notably for vessel operators, hull cleaning restrictions vary in form and can be imposed by international accord, country, state, and contractually by the vessel's owner or insurer. The following provides a sample of regulatory approaches to controlling the spread of biofouling.

Table 4. Identified Criteria

Criteria	Significance
Company	A company's objectives and expertise will determine the technologies and methods used in the robotic mechanisms, software, and methods for fouling removal. A company's longevity, reputation, and intellectual property portfolio can indicate the reliability of a company's ongoing support and strategy.
Country of origin	It is important to know where the technology is being developed and whether the majority of the companies are from specific regions. Understanding where these companies are headquartered is vital because each company may be targeting different regulatory requirements. It's also helpful to understand the diversity of available technologies.
Robot weight	The weight of the robot may indicate the payload it is able to accommodate. It can also reflect on the size of the ship it intends to target, though it is not a direct connection.
Robot size	The size of a hull cleaner largely dictates the spaces it will be able to access. The size also gives an idea of the amount of fouling it will be able to process, much like weight.
Adhesion technique	Different hulls will require different adhesion techniques. Some adhesion techniques may also be susceptible to falling off the side of a ship if there are extrusions or inlets in the hull.
Adhesion force	The robot must be able to remain attached as long as intended. Currents and waves must not be able to dislodge the robot during operation.
Cleaning speed	The cleaning speed of the robot is vital, as some of them clean very slowly. Very large ships will need large robots to be able to clean in a short period of time.
Type of cleaning apparatus	The type of cleaning apparatus will determine the functionality of the robot. For example, using water pressure will pose different challenges than using brushes.
Sensors included on platform	In order to properly understand the full capabilities of the robot, it is important to know the full suite of sensors the platform has installed.
Is the robot able to function while ship is underway?	If the vessel's operational demands require short port stays with no delays, this capability may be important.
Does the robot use a filter?	Due to current regulations on water cleaning of ships, it is important that hull cleaners do not cause unnecessary discharge of either antifouling paint or marine life.
Mean time to failure	It is important to know how long a specific hull cleaner is expected to last before it is necessary to replace the system or perform large-scale maintenance/repairs.
Operational style (Autonomous, semi autonomous, manual control)	The operation style of a hull-cleaning robot dictates the management of the robot in terms of its daily life on a ship. If a robot is autonomous, daily operation remains unaffected. If the robot requires manual operation, it is important to understand who will operate it and how.
Tethered or free swimming?	A tether poses risks of entanglement, but can also prevent loss and retrieval efforts.
Cost	As with any technology, cost affects its ability to perform. A high-cost device should produce excellent results.

International Maritime Organization (IMO)—IMO adopted guidelines for the control and management of ship's biofouling in July 2011, identified as Resolution MEPC.207(62) or "Annex 26." The guidelines recommend a series of best management practices including installing an anti-fouling system, creating a biofouling management plan, and maintaining a biofouling record book. The guidelines are instructive yet do not establish any quantifiable standards or limitations in terms of biofouling growth to maintain. Therefore, the application of the best management practices is discretional and not enforced.

New Zealand—New Zealand has adopted regulations to regulate biofouling on ships entering their ports and waters that will take effect in May 2018. This regulation distinguishes all ships entering its waters as long-stay vessels or short-stay vessels.

Long-stay vessels are any vessels that stay 21 days or more in New Zealand. Vessels are automatically "long-stay" if they plan on visiting any place other than those that have been designated as Places of First Arrival, which are designated in the New Zealand Biosecurity Act as areas that accept vessels into New Zealand. Long-stay vessels have to meet very simple but rigorous standards for the amount of biofouling they can have. Long-stay vessels are allowed to have no more than a layer of slime and goose barnacles present on their entire hull surface. Unlike short-stay vessels, long-stay vessels must follow this standard for all parts of their hull.

Short-stay vessels are vessels that stay 20 days or less in New Zealand, and only plan on visiting areas designated as Places of First Arrival. Short-stay vessels have three different sets of standards and regulations they must meet for three different sections of their hull. There are regulations specifically for the wind and water line of the hull, the main hull area, and niche areas of the hull. These sections each are unique in what is and is not allowed to accumulate in terms of biofouling.

For the wind and water line, the short-stay vessels are allowed to have green algae growth as long as it is no more than 50mm in frond, filament, or beard length. Brown and red algae are also allowed as long as it is not more than 4mm in length. The wind and water line can also have incidental coverage of one organism type, which may include tapeworms, bryozoans, or barnacles. This incidental coverage cannot cover more than 1 percent of the total area, can be isolated individuals or small clusters, and can only be made up of a single species or what appears to be a single species.

The main hull area of short-stay vessels cannot have algae growth of more than 4mm in length. Additionally, they cannot have continuous strips and/or patches of more than 50mm in width. Like the wind and water line, they are permitted incidental coverage.

Niche areas, such as sea chests and propeller cavities, on short-stay vessels are permitted to have algae growth of more than 4mm in length. Continuous strips or patches of algae can exceed no more than 50mm in width. Unlike the other parts of the ship, they are permitted to have scattered coverage of one organism type. These can be either tubeworms, bryozoans, or barnacles. This incidental coverage can account for a maximum of 5 percent of surface area. Organisms may be widely spaced, infrequent patchy clusters. Organisms are not permitted algae overgrowth and must appear to be a single species. Just as the main hull area and wind and water line can have incidental coverage, so may niche areas.

United States—The 2013 National Pollutant Discharge Elimination System General Permit for Discharge Incidental to the Normal Operation of a Vessel, referred to as the Vessel General Permit (VGP), applies to commercial non-fishing vessels within three nautical miles of the United States. VGP Part 2.2.23 requires vessel operators to minimize the transport of attached

Table 5. Changing Status of Hull Cleaners

Product Name	Company/ Developer	Operating Type	Filter	Holding System	Cleaning System
CleanHull	CleanHull Ltd.	Semiautonomous	Yes	Turbines	High pressure water
Envirocart	GRD Franmarine Holdings Ltd.	Semiautonomous	Yes	Diver Driven	Rotating disk brushes / blades
Fleet Cleaner	Fleet Cleaner	Manual	Yes	Magnets	High pressure water
GreenSea	Raytheon Company	Autonomous	Yes	Neodymium magnet track system	Brushes and ultrasonic vibration
Hull Surface Treatment	Commercial Diving Services Pt. Ltd.	Manual	No	Magnets	Thermal shock
Hullbot	Hullbot Ltd.	Manual	No	3 Thrusters	Cleaning rotating disks
HullBUG	SeaRobotics Corporation	Autonomous or Semiautonomous	Yes	Magnets / Negative Pressure	Brushes, water jets
Hulltimo	Hulltimo	Manual	Yes	Suction system	Brushes, roller of polyamide
HullWiper	Gulf Agency Company EnvironHull	Manual	Yes	Negative pressure system	Cleaning discs that pump saltwater
KeelCrab	Sail One Aeffe s.r.l	Manual	Yes	Turbine	Turbine vacuum, rubber and nylon brushes
M6 Sub Sea Cleaning Tool	VertiDrive	Manual	Unknown	Magnets	High-pressure water nozzles
Magnetic Hull Cleaner	Technip Cybernetix	Manual	No	Magnets	Pressure washer
Mini-Pamper	UMC International	Manual	Yes	Diver Driven	Brushes
Remora	Remora Marine	Autonomous	No	Diver Driven	Brushes, pads
Roving Bat	Sea and Land Technologies Pte. Ltd.	Semiautonomous	No	Thrusters, motorized tracks	Hydrojetting or a brushing system
Submersible Cleaning and Maintenance Platform (SCAMP)	Seaward Marine Service, Inc.	Semiautonomous	Yes	Diver Driven	Brushes
Hull Surface Treatment (HST)	T & C Marine (Div. of Thomas & Coffee Ltd.)	Manual	No	Operated from Tender	Thermal shock
Underwater Hull Cleaning Robot	Samsung Heavy Industries	Proprietary	Yes	Proprietary	Proprietary
Whale Shark	Whale Shark Environmental Technologies Ltd.	Semiautonomous	Yes	Propeller	Brushes

living organisms from overseas or between Captain of the Port zones. It recommends regular cleaning of hulls and niche areas to minimize the transport of attached living organisms.

While the permit recommends best management practices, it does not create an enforceable standard. For instance, the permit recommends limiting the use of hard brushes when in-water cleaning as well as proper collection and disposal of antifouling debris resulting from in-water cleaning. This permit is expected to be replaced by the next version of the VGP on December 20, 2018. Whether or not the next VGP includes additional requirements concerning hull cleaning is yet to be determined.

A sailor scrapes barnacles from the bottom of a rigid-hull inflatable boat aboard the aircraft carrier USS *John C. Stennis*. U.S. Navy photo by Seaman Apprentice Christopher Frost.

States are encouraged under the Clean Water Act to apply and enforce these regulations, but until now there has been limited effort to inspect and enforce regular hull cleaning. Nonetheless, several states have either passed or proposed regulation that biofouling allowed to accumulate and mature without hull cleaning is determined to be an illegal discharge.

Industry-Related Initiatives—In May 2013, the Baltic and International Maritime Council (BIMCO) shipping association, described as the world's largest international shipping association, adopted the BIMCO Hull Fouling Clause as an industry standard for chartered vessels. The clause establishes a standard only for vessels that are idle in Tropical and Seasonal Tropical Zones for more than 15 days because of an anticipation of non-contracted cost, expense, or time attributable to biofouling. This clause recognizes warmer marine water temperatures and the time that a vessel is idle as conditions that favor hull fouling. The clause provides that an owner may inspect a vessel at any time and require cleaning, both at the charterer's expense.

Fuel Costs and Hull Maintenance

The motivation for removing fouling organisms from the hull is not simply due to meeting regulatory compliance. Fouling organisms create drag and can weaken the integrity of a hull if left unabated.

Fuel Costs—There is much analysis and conclusion that fuel consumption directly relates to hull smoothness. Likewise, correlating the loss of hull smoothness with biofouling is well documented. The calculations correlating biofouling with fuel consumption are principally based on frictional resistance as influenced by the Reynolds Number for calculating the turbulence value of an object relative to the surrounding gas or liquid medium.

Estimates of fuel cost have been attempted. They range depending on multiple factors such as hull length and shape, engine and fuel efficiency, temperature and salinity of the water, and particular makeup of the biofouling. For instance, Fathom Shipping cites previous data from Bellona and the Clean Shipping Coalition indicating that one-tenth of the world's shipping fuel costs are attributable to biofouling, and that anti-fouling protection saves 72 million tons of fuel consumption annually.[2] Another article, available on www.gCaptain.com and submitted by Propulsion Dynamics, Inc., estimates that if a VLCC vessel consumes 15 tons of fuel more than the optimal design estimates, that seven tons—or nearly half—of this is a fuel/power penalty attributable to hull fouling.[3]

Other research estimates that a slime layer accounts for 8–18 percent of propulsion power, calling it a "power penalty," whereas thicker macrofouling and calcium deposits from certain species such as algae, mussels, and other bivalves can account for 80 percent of a vessel's propulsion power output.[4,5] Hydrex Underwater Technology, in their white paper entitled "Ship Hull Performance in the Post-TBT Era," presented a range of 9–84 percent power penalty attributed to hull biofouling.

Pinpointing exact fuel or power penalty caused from biofouling can be approached in many ways and vary in its results. However, there is consensus that a sizable fuel cost results from allowing biofouling organisms to settle and remain on the hull during transit.

Prevention of Corrosion—Maintaining the hull's integrity and preventing corrosion are a part of fundamental vessel maintenance and, to some extent, encourages an operator to prevent biofouling from becoming a nuisance and interfering with the vessel's mobility and function.

Fouling organisms range from the microscopic to very large colonies of barnacles and other mollusks. Similarly, algae species range from red and green varieties that grow to a maximum of millimeters to brown algae that can grow to over 25 meters in length and more than 1.5 meters in one day.[6]

An important factor in the persistence of these species is the adhesion techniques these organisms employ. For instance, mussels and barnacles have been documented as having a tensile strength of 5,000 pounds per square inch and an adhesion strength that has been measured at 22–60 pounds per square inch.[7] Organisms like these that can develop attachment forces such as these should be removed regularly to prevent mature colonies from forming.

Without regular removal, the cumulative added weight of biofouling can become significant depending on the length of the hull, the species, and the thickness of the fouling. If left unchecked, these characteristics of biofouling—adhesion mechanisms and mass—can be significant threats to a hull's performance.

Conclusion

There are several influences on the development of the robotic hull-cleaning industry. Unless ship operators are motivated to clean their hull and invest in robotic hull cleaners to help them achieve that goal, there is no demand to encourage the industry. Influences creating demand are the potential for fuel savings, compliance with regulation, and contractual obligation of charterers. For robotic hull cleaners to become more popular, it must be made known that their performance is a proven method for reducing drag and removing biofouling without disproportional risk to the vessel or operator.

Manufacturers have multiple capabilities they need to meet based on the region, vessel type, and operating conditions for removing biofouling without polluting the environment. Considerations are complex and include the number of divers needed to operate or deploy the device; permissible areas where it can be operated; and risks associated with malfunction, damage, and loss of the hull cleaner. When balancing multiple factors, the hull cleaner should not create more risk than would outweigh the benefits of hull cleaning. Given the variability of regulations around the world, as well as that of hull designs, manufacturers may choose to specialize in a niche customer or location.

The existence of about 20 manufacturers indicates that the combined incentives to reduce fuel costs, comply with regulations to prevent invasive species, and maintain the hull are sufficient economic pressures for some vessel operators to purchase these devices. Today, only New Zealand has set a numeric standard for allowable biofouling. However, if best management practices become more defined and enforced—possibly to prevent invasive species or reduce fuel consumption—this industry is likely to expand. Existing companies that have invested efforts to overcome technical challenges are on their way to carving out niches in the market.

About the authors:

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The authors completed a 2016 team internship at Coast Guard Headquarters where they studied the issue of vessel hull cleaning. That work served as the basis for this article.

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Marine Inspections 2050

A day in the life of a future USCG marine inspector

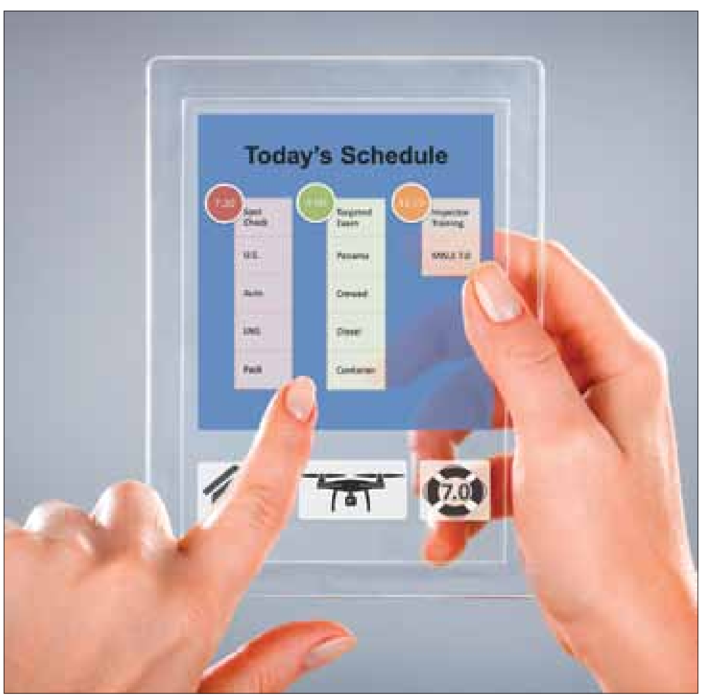
by CDR Tracy Phillips
Chief, Tank Vessel & Offshore Division
Marine Safety Center
U.S. Coast Guard

LCDR Frank Strom
Assistant Chief, Inspections Division
Sector San Francisco
U.S. Coast Guard

LT Ryan Mowbray, P.E.
Marine Inspector
Sector Puget Sound
U.S. Coast Guard

Pat props up a portable, tablet-sized workstation and scrolls through the day's schedule.

7:30—Routine Spot Check, U.S. flag, Autonomous, LNG fueled, Short-sea, PackFreight
9:00—Targeted Exam, Panama flag, Crewed, Diesel, Container
12:15— Inspector Training – MISLE 7.0
1:30—PSM Shipyard, Annual/Drydock, U.S. flag, Crewed, Combo (Solar super steam & hyper efficient sails), Co-Pax



Scrolling through the day's schedule. Schedule by author; hands holding tablet by Andrey Armyagov/Shutterstock.com.

I wonder if this will be like the last two autonomous vessel inspections? Maybe this vessel will actually have its security system ready for review when I arrive.

I wonder what the intelligence is on the 9 o'clock? Maybe the satellites detected a sheen from them during their last voyage?

Hmm … the afternoon inspection has one of those new solar super steam plants. I've only read about those. I'll have to get some support from the master MIs on that one.

Pat opens up the records for each vessel and begins reviewing their histories. The database includes options to view the inspection history, a map of the vessel's tracklines, a log of alarms, a list of prior deficiencies, and a record of near-miss incidents.

Just then, a picture of Pat's supervisor appears in the upper corner of the workstation, displaying a live video feed when the call is answered.

"Good morning, sir. How are you today?" Pat says.

Frequent check-ins with the supervisor alleviate the feeling of isolation that often accompanies detached duty. Despite never having met in person, there is always a feeling of connection with the chain of command.

"Great, thanks. It's a busy day—let's get right to business. What do you think of your schedule today? Will you need any assistance?"

"Yes. Can you arrange for the master inspectors to join me for the inspection of the solar super steam system this afternoon?"

"Roger. I'll let them know to expect your call around 2. I'll have Dan and Joe meet you at the targeted exam at 9. We're still waiting on the intelligence feed to explain what they're looking for. Also, I just got word Training Center Yorktown is teaching a law enforcement class about autonomous vessels. Could you show them around the vessel this morning?"

"Of course."

"Thank you. Have a good day. Talk to you this afternoon."

"Sounds good. Have a good day, Sir."

Pat checks the clock and gathers some safety equipment before hopping into the car and issuing a command.

"To the port. Pier 6."

"Yes, Pat. Beginning drive now. Traffic is light. Your travel time will be 14 minutes," an automated voice responds.

Once on the dock, the automated car voice announces its arrival at Pier 6. A quick look out the window reveals the autonomous vessel a short distance away.

Reaching into a bag, Pat removes and dons a set of inspection glasses. After a brief start-up sequence, the glasses project a heads-up display of the inspection checklist.

A set of inspection glasses. Illustration by author; eyeglasses by Rangizzz / Shutterstock.com.

The next item out of the bag is a small underwater drone. After a quick check to ensure there are no other vessels nearby, Pat tosses the drone in the water and watches it zip along the surface towards the autonomous vessel.

A message flashes on the display of the glasses—TRAINING CENTER. A tap to the right side of the glasses answers the call.

"Good morning. This is Margaret from Training Center Yorktown. We have Law Enforcement Class 01-50 here, ready to view your inspection."

"Roger. Do you have a clear video and voice feed?"

"Yes on both."

"Good morning! My name is Pat, and I will be your marine inspector guide today. We will be touring a U.S.-flagged commercial autonomous vessel. The vessel's propulsion power comes from liquefied natural gas, and the vessel is designed to carry packaged freight cargo on short-sea shipping routes. Before we get started, are there any questions?

"No? OK—let's begin. Autonomous vessels have sensor-activated security measures in place to prevent unauthorized access, so prior to approaching an autonomous vessel, you should always call the vessel's designated master, or DM, ashore.

"This person is available 24 hours a day, has a live feed of the vessel's operating information, and can disarm the security system to provide you access to the vessel. Our MISLE database has the DM's contact number.

"When you tell the DM that you want to go aboard, they'll authenticate your identification through the Coast Guard's Commercial Vessel Engagement Center. Today's inspection has been prearranged with the DM, so we should be able to go aboard immediately. Even if you haven't prearranged a boarding, though, most DMs are very familiar with this process, so it usually goes quickly."

Pat calls the DM and requests permission to board the vessel for the inspection.

"Hello! I can see on the video feed that you are on the dock, and I'm disabling the security measures now," the DM says. "You are authorized to proceed. If you need anything, just let me know or ask the ship's computer."

At the top of the bow, an automatic security gate blocks the way. The gate swings open, and a friendly, robotic voice says, "Good morning, Pat, and welcome aboard! If you need any information during your inspection, please connect to one of the onboard terminals."

"These autonomous vessels are quite straightforward to deal with," Pat tells the class. "Since there's no crew, all of the spaces fall into four categories: machinery, cargo, ballast, and voids. The main computer can control the entire ship from any of the terminals onboard, and the terminals are located on every deck, no more than 25 frames apart.

"Since the main computer is so important, the first thing you should always do is check the validity of the system's digital certificates."

Pat walks the students through the digital certificate verification before continuing.

"The next step is to examine the critical systems and spot check several alarms, monitors, and video feeds, paying particular attention to navigation, propulsion, stability, and fire detection. This allows you to check for corruption or improper readings, as well as assess the DM's competence. The first thing we'll look at today is the LNG plant."

Walking to the nearest terminal on the main deck, Pat plugs in the inspection tablet and begins diagnostics on the liquefied natural gas plant. A 3-D model of the LNG system, its performance metrics, and a listing of alarms appear.

Within moments, some anomalies that had occurred about three months prior become apparent. Unusual vibrations were detected in one of the onboard generator sets, triggering an alarm at the shore-based operations facility. A full report of the alarm shows up along with the detailed follow-on actions. This and a video of a technician fixing the failed engine mount satisfy Pat that the operator is maintaining the LNG plan in excellent condition. Several alarms and monitors are selected for a spot check, and the students are walked through the process.

Pat also checks the other critical systems, then conducts a deck walk and a walkthrough of the machinery spaces, pointing out other unique features of autonomous vessels and identifying several minor deficiencies.

"OK! All that's left is to go pick up the underwater inspection drone."

A quick walk to the bow of the vessel reveals the underwater drone, having completed the hull survey, sitting on the forecastle deck, awaiting recovery.

"The drone, deployed before boarding the vessel, used a sophisticated sonar system to scan the surface of the hull," Pat explains.

"How did it get out of the water?" a student asks.

"Once the drone has completed the hull survey, it returns to the end of the vessel with the most taper, which means the bow, for most ships. It activates an internal electromagnet, attaches to the hull, and climbs up to the deck.

"As you can see from this display, the drone did not observe any anomalies in the hull," Pat notes, looking at a small indictor screen embedded in the top of the drone. "If anomalies are detected, you can view a 3-D model of the hull on your portable workstation, which allows you to evaluate the issue and determine the proper course of action."

Satisfied with the results, Pat logs the inspection and the outstanding deficiencies in the ship's main computer, then answers questions for the class while heading towards the car.

With the inspection complete, Pat uses the tablet to complete the casework. In a span of just four minutes, Pat:

- scrolls through the inspections checklist
- marks off the completed items
- links the results from the underwater drone to the case
- links the video feed from the inspection glasses

At the next vessel, Pat is greeted by two Coast Guardsmen.

"A drone sampled the vessel's emissions as it passed the virtual sea buoy. The analysis shows that its sulfur emissions exceeded the allowable limit," Dan says. "Since this is an older vessel, the onboard fuel log and sensors aren't tied into AIS-Plus, so we are supposed to collect that information. The investigator would also like to ask the master a couple of questions to determine intent."

"Great—thanks for that briefing, Dan. Do you have the names of the folks who want to join in and watch our exam?"

"Yes," Dan replies, listing the intelligence officer, the investigator, and the lawyer involved in the case.

Pat uses the inspection glasses to establish an audio-visual connection with the individuals.

"We have everyone," Pat says. "Let's get onboard."

The team boards the vessel and is greeted by the watchstander. After Joe sets up a portable communications booster, they're escorted in to see the master.

"Good morning, Captain. We're here today to discuss your vessel's fuel system," Pat explains, asking if the chief engineer can join them. "While we're waiting for the chief, I would like to remind you of the Coast Guard's cyber security enforcement provisions. The Coast Guard is using a secure communications system while onboard your vessel today. In accordance with the Cyber Security Protection Act of 2025, any attempt to intercept or alter government communications is punishable under U.S. law. If we detect any interference today, it could result in fines or imprisonment."

When the chief engineer arrives, introductions are made, including those Coast Guard members participating remotely.

When they ask, the chief engineer indicates he's most comfortable conversing in Mandarin. Pat explains the translation feature of the inspection glasses.

The team begins asking general questions about the vessel's propulsion system, the types of fuel used, and whether any equipment is out of order. They hear the engineer's responses in Mandarin, and see a translation through the inspection glasses. The team beings relaying the intelligence officer's questions about the information previously gathered by the drone.

Determining that the crew was unaware of the problem, everyone heads to the engine room where the crew is troubleshooting the propulsion monitoring system. They discover a faulty sensor causing the slightly elevated sulfur emissions.

In the future, a drone like this may be used to sample vessel emissions. Photo by Prazis Images / Shutterstock.com.

The engineers immediately replace the sensor, and several tests ensure the issue is corrected. The exam concludes.

Pat heads for a private meeting room at a local coffee shop to virtually participate in the afternoon's training session. As the tablet connects to the virtual training room, the session begins.

"Good afternoon. I'm Kelley, and I'll be providing today's training on MISLE 7.0. Since all of you are marine inspectors, we will focus our attention on the system's features you will use most."

The training concludes and, while Pat takes a few minutes to go over the inspection checklist for the next vessel, a message arrives from the supervisor indicating that Mike, a new trainee, will be joining the next inspection. Mike will also run the fire drill today, and the training officer will be remotely observing the drill. Pat acknowledges the message and heads to the shipyard, where Mike is waiting in the parking lot.

The captain greets them at the top of the gangway. After the standard cyber enforcement reminder, the captain comments on how long it's been since the ship's last Coast Guard inspection.

"There are a wide variety of risk factors which influence the vessel's inspection frequency, including its age, the owner's history, the number of alarms received via AIS-Plus, the quality of the near-miss reporting, and the results of previous inspections," Pat says. "All the information is consolidated in an assessment matrix. Based on the number of resources available at any given time, sometimes a low-risk vessel like yours can go several years without a visit from the Coast Guard.

"The first item we'll need to see today is your International Ballast Pollution Prevention certificate," Pat continues, as they head to the bridge. "For some reason, the automatic upload of the ship's documents did not capture the issue date."

The captain opens up the certificate on a tablet so Pat can check the validation key and confirm the date of issuance. Pressing a button on the inspection glasses, Pat records the information.

The words "Confirmed IBPPC is valid. Issue date 6 January 2050" show up on the display of the inspection glasses. With another tap of the button, the entry is accepted and the inspection status bar changes to 3 percent complete.

The chief mate begins walking Pat and Mike around the weather deck. As they pass a container, they notice its labeling is almost unreadable. Mike scans the code on the placard, and pulls up the container profile.

"Chief, this container is loaded with highly toxic benzene derivatives. Please replace this label with a new one," Mike directs. The chief radios instructions to the boatswain. They discover several other deficiencies, including a bad gasket on a watertight door and an inoperable 3-D display of the fire control plan on the main deck are identified before the team moves on to the void space exam.

Pat readies the confined space entry robot that operates as a mini-helicopter outfitted with wheels, an array of sensors, and atmospheric monitoring. The robot buzzes through the manhole and begins scanning within the void.

These robots are a life-saver! No more crawling through impossibly tight spaces, and no more worrying about the dangers of confined space entry!

"Did you really have to crawl through all of these tanks when you were a trainee?" Mike asks.

"Yes," Pat answers. "For a U.S. vessel operating in salt water, we would crawl inside the voids once every two or three years. Those types of inspections were very time consuming. The introduction of these robots allowed us to reduce our average inspection time by 36 percent."

Reviewing the inspection checklist for the next vessel. Schedule by author; hands holding tablet by Andrey Armyagov / Shutterstock.com.

The robot pops up out of the void, landing on the deck. Pat walks over and picks it up. After reviewing the results, they let the chief know the robot has detected deflection in one area of the bulkhead and micro-cracks in some of the surrounding frames. In order to prevent cracks from developing, the crew will need to assess the structure with the installation of stress monitoring equipment. Mike verbally records the results in a deficiency list.

"Chief, I think we're ready for a fire drill," Mike says. "Let's simulate a fire in the passenger cabin on the fourth deck."

"Roger," the chief says, pulling out a bright red phone labeled *Fire & Damage Control.*

At the same time, Pat makes a call to the regional training officer, who "joins" the inspection just as the chief verbally initiates the drill.

A few seconds later, the general alarm rings, and the crew scrambles into action. Almost immediately a notification pops up on the fire control phone noting that the engineers have secured power and ventilation in the affected space.

Mike and the chief make their way up to the passenger cabin, using the fire control phone to track the locations of each crew member. The chief lets Mike know when the fire team is dressed out and when boundary cooling is in place. They arrive at the cabin just as the fire team is accessing the space. Mike observes their firefighting tactics and looks over the team's gear.

"OK, drill complete," Mike says. He asks the team about overhauling a fire, and provides the chief with feedback on the drill. The team then runs an abandon ship drill, and Mike finds that the second engineer's personal locator beacon is not properly registered in the system. Using the inspection glasses, Pat records the results of both drills and links them to the inspection checklist.

Pat asks for the chief engineer to join them, so they can begin the inspection of the propulsion system, then calls the headquarters office of master marine inspectors. This office provides centralized training and assistance during inspections involving complex, novel, and historic ships or systems.

"Thanks for joining us today," Pat says. "We are onboard a U.S. flag container-passenger ship with a Solar Super Steam propulsion system and hyper-efficient sails."

"Happy to help," the master inspector says. "I see you are out on deck. Let's start by taking a look at the sails, the connection points, and the solar panel array."

The master inspector guides Pat and Mike through the critical inspection points on the system, explaining how it works as they go. The group moves to the engine room, and the chief engineer shows them to the super steam generator and piping. When the propulsion system check is complete, the inspector asks to watch the drydock inspection.

"No problem," Pat says, turning to the chief mate and chief engineer. "As you are aware, the ship is due for a Coast Guard drydock exam. Do you have a hull gauging report?"

"Yes, we completed the survey yesterday. Let me pull up the report," the chief mate says, finding the report on his tablet.

"I see that all of the hull thicknesses are within tolerance," Pat notes. "Are you ready to show us the critical inspection points?"

"Yes. We have the underwater inspection drone hooked up to the air bubble, so we're ready to look at anything you would like," the chief engineer says.

When asked why it's called a "drydock" exam, Pat explains the name originated when the exam was conducted out of the water and, though most of the work is now performed in the water, the terminology never changed.

"Great. Let's start by looking at all of the hull penetrations, and then move to the rudder, propeller, and shaft."

Everything goes well with the drydock exam, and the team parts ways with the vessel crew.

Pat heads back to the car and sets a course for home. On the drive home, there is just enough time to make a final check in with the supervisor.

"Good afternoon, Sir. I have completed my inspections for today," Pat says.

"I was just going to call you. How did everything go?"

"Really well. You'll see in the casework that we had a few minor issues, but nothing major on any of the ships. I learned quite a bit from the master inspectors this afternoon. Mike did really well during his drill for the regional training officer," says Pat.

"Great! One final item for today. I got a call from one of the cutters about five minutes ago. They are on-scene with a sinking fishing vessel. The cutter used an underwater drone to obtain video of the damage to the hull. The fishermen want to stay onboard to dewater the vessel, and the cutter CO wants to consult with an inspector prior to making the final decision. It's a wooden boat, and you are the region's only inspector with a wood boat qualification. Do you have a few minutes to take a look?"

"Of course."

They review the video clip, and, after a brief discussion, they call the cutter to provide some recommendations, which helps inform the decision to allow the crew to remain onboard.

After hanging up, Pat reflects on the day's events.

It's amazing how much technology has proven to be a game changer for marine inspectors over the past 20 years!

About the authors:

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LEADERSHIP

Leadership in Routine Emergencies and Crises

The *Deepwater Horizon* incident

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Leadership in emergencies is a crucial element of becoming a high-performing Coast Guard officer. In this article, we argue that emergency leadership is not a single skill or uniform set of organizational competences. Instead, we identify a spectrum of emergency situations, ranging from what we will call "routine emergencies" through "crises," differentiated by increasing degrees of novelty in the emergency challenge.[1] Leaders and their organizations must develop capacities for managing in both types of situations.

Over time, societies have developed specialized organizations to deal with emergencies, including emergency management, police, firefighters, emergency medical technicians, and emergency medicine. By far the most common form of emergency they face is what we have elsewhere termed "routine" emergencies.[2] These situations are not necessarily small in any sense. In fact, they may be quite large and dangerous. We call them routine because these hazards can be anticipated, even when their timing, scale, and precise location cannot be predicted. Routine emergencies occur frequently enough that organizations can frame and inform expectations about future incidents.

It is this degree of predictability that allows society to prepare in advance and thereby reduce the harm that such emergencies might otherwise cause. This is highly important because the vast majority of emergencies that arise are routine in this sense.

The professionalization of emergency services over the past century and more has made life safer and protected property and other values in ways that earlier generations could only dream of. It also has resulted, in large part, because organizational leaders anticipate emergencies by type and have prepared responses.

Most importantly, leaders prepare by framing plans to avert, minimize, or respond to routine emergency events. They train, equip, and exercise individual responders so they will be ready when needed. They devise coordination methods and practice implementation of response tactics. They also strategically station critical resources—people, equipment, supplies—in appropriate places so a response can be launched rapidly. In turn, when an emergency actually arises, responders can deploy resources effectively. Ideally, over time and through repeated occurrences, organizations, leaders, and individual responders develop experience with many types of emergencies and become highly proficient in handling them.

Excellence in Routine Emergencies

What constitutes excellence in responding to routine emergencies?

Effective preparedness includes a robust set of contingency plans for anticipated scenarios, combined with people who have strong training, skills, practice, and actual operational experience. Coordination methods are well established and drilled. When routine emergencies occur, responders know what factors matter and therefore what to look for. As they determine what they are facing, they typically trigger standard operating procedures that all experienced personnel have practiced, and often employed, before. Of course, any emergency has distinctive features, and these are accommodated through real-time customization of standard operating procedures. But the basic approach to routine emergencies has been set in advance. When well prepared for routine emergencies—even very large or dangerous ones—response organizations can act

Workers from the BP contracted company SWS offload boom to pre-positioned areas along Lake Powell, May 11, 2010. U.S. Coast Guard photo by Petty Officer Renee C. Aiello.

with confidence, discipline, a sense of purpose, clarity about what needs to be accomplished, and well-honed skills.

Expertise and Hierarchy

Leadership in routine emergencies is expertise-driven and usually hierarchical. Leaders know what to do because they've trained for such situations and performed well before. Ideally, they are chosen for their knowledge, effectiveness during prior events, and demonstrated capacity to function under pressure. They exercise authority directly and expect compliance from their subordinates, who follow them because they have confidence in their leaders' proven judgment.

Following events, leaders are accountable for results. They are evaluated by how those results compare to what has been achieved in similar events. At their best, response organizations can aim for operational precision and high efficiency in routine emergencies.

To say an emergency is routine does not mean it may not be hazardous and have substantial scale. Nor does this terminology imply the organizational capabilities that enable effective response are in some sense ordinary. To the contrary, it is a huge achievement for response organizations to develop, refine, and keep well-honed the multiple capacities that enable them to deal with potentially tragic or costly occurrences. In fact, the histories of each type of emergency response profession can be told as narratives in which increasing numbers of previously unmanageable hazards were turned into tractable—routine—response problems.

Routine Emergencies in the *Deepwater Horizon* Response

From this perspective, the Coast Guard can be regarded as an organization whose missions, in very important elements, require preparation for a wide range of maritime emergencies, many of which can be anticipated in general type and are therefore routine in the manner that we use that term in this article.

The *Deepwater Horizon* incident illustrates this in a number of ways.[3] The oil drilling platform explosion, fire, and sinking were extremely dangerous and terrifying to the people affected. The long-lived, uncontrolled outpouring from the undersea oil well created unprecedented costs and serious effects for individuals, businesses, communities, and governments in the region. But for many in the Coast Guard, the response was not unprecedented. It called for skills and practices developed well in advance.

In the immediate aftermath of the explosion, teams deployed for search and rescue operations that drew on fundamental Coast Guard practices and experience. As the extent of the disaster and the immediate consequences were perceived, the Obama administration organized its overall response under the Oil Pollution Act of 1990 (OPA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Under OPA, which gives the federal government authority to direct responses to large-scale oil spills, the Coast Guard is the lead federal agency for coastal spills.

Two days after the fire, when the *Deepwater Horizon* sank to the ocean floor, the administration expanded its response, still pursuant to protocols articulated in OPA and the NCP. It established a unified area command, in which representatives of the affected states, the federal government, and BP, as the responsible party, could coordinate a multi-jurisdictional, multi-agency, multi-sector, and intergovernmental response. A very experienced commander, Rear Admiral Mary Landry, head of the Coast Guard's Eighth District, took the lead, serving as the federal on-scene coordinator.

U.S. Coast Guard Commandant Admiral Thad Allen meets with Rear Admiral Mary Landry, the federal on-scene coordinator for the *Deepwater Horizon* incident, and other local, state, and federal members participating in the unified command to discuss leveraging every available resource to respond to the British Petroleum oil spill and minimize the associated environmental risks in May 2010. U.S. Coast Guard photo by Petty Officer Michael De Nyse.

Under this organizational structure, in the weeks and months that followed, the Coast Guard and its partner agencies undertook a complex set of activities related to the direct impacts of the oil rig's explosion and sinking. It investigated the causes of the accident, the increasingly complex oil leak cleanup, and the widening circles of consequences for the Gulf oil industry, fisheries, and regional tourism.

These activities often required policy and organizational innovations, many of which originated out of the National Incident Command (NIC), that were established as a layer above the unified area command, since the event was much more complex and novel than it had first appeared. Even then, in many respects, the massive response efforts that took place over several months involved capacities and practices of oil spill cleanup and mitigation, regulating sea traffic, and safety that the Coast Guard had developed and institutionalized long before.

Fortunately, the Coast Guard was able to reap the many benefits of having turned significant aspects of the problems it had faced into routine emergencies rather than crises. That these accomplishments in the *Deepwater Horizon* aftermath were sometimes given less than deserved political and public recognition does nothing to diminish the achievement resulting from years of organizational development.

The Distinguishing Features of Crisis Leadership

On the spectrum of emergencies, we differentiate a "crisis" from a "routine emergency" by one key trait that has many consequences. By contrast with routine emergencies, crises involve substantial *novelty*—characteristics of the emergency that have not been previously encountered by the organizations or people involved.[4]

Novelty may stem from several different sources. The most common is an event that, while anticipated by type, is so large in scale that it exceeds the planning frame and the resources ready to deploy in response. A second source of novelty is an event that is truly unprecedented—a "new under the sun" event—for which no plan has been prepared and that may require improvising in response. Or, third, novelty may arise from a combination of emergencies that occur at the same time or close together. Each of these may have been prepared for separately, but the conjoined occurrence may confuse previous plans, or overload responders.

Crises put enormous strain on the entire response system, including simultaneously engaged response entities. In a prototypical crisis, the multiple dimensions of situational awareness—gathering information and assessing what is happening, projecting likely future results, and conceiving and implementing appropriate actions in response—are very weak in comparison to what happens in routine emergencies. Rank and file responders, and even leaders, may feel events and consequences are out of control and beyond their usual operating capabilities, generating very high stress.

Although responders may have experience with some aspects of the situation, in novel circumstances no single leader or decision maker is a comprehensive expert. Rather than depending on standard operating procedures or checklists, they have quite limited "scripts" to rely on.

Clouds of smoke billow up from controlled burns taking place in the Gulf of Mexico in May 2010. They were set to reduce the amount of oil in the water following the *Deepwater Horizon* oil spill. U.S. Coast Guard photo by Chief Petty Officer John Kepsimelis.

Strategy and actions must be improvised to meet unprecedented demands, in part by piecing together existing plans and capacities in new combinations, as well as through innovation. Plans and tactics may have to be adapted and re-adapted as the situation unfolds, perhaps in repeatedly unexpected directions. But improvisation under the pressure of crisis entails heightened risk. Under normal conditions, for reasons of effectiveness and safety, response organizations generally prefer to develop and execute new capabilities cautiously and only after careful planning, training, and practiced implementation. In crises, that prudent approach is often not possible.

Sudden Versus Emergent Crises

We can distinguish two patterns by which crises arise. The first may be termed a "sudden" crisis, an event clearly beyond routine that occurs with dramatic visibility. For example, a no-notice natural disaster, like an earthquake, a severe technology failure, or a terrorist attack would constitute a "sudden" crisis.

The second is an "emergent" crisis—an event that at first appears to be routine but at some point, gradually or dramatically, transforms into a novel occurrence that goes well beyond the plans and capacities designed for routine emergencies.

Both types of crises are difficult to deal with, but emergent crises pose special response problems. It may prove initially difficult for the responders deployed to the scene to recognize the gradually evolving break between the characteristics of a routine emergency and those that constitute a crisis. This is especially true when normal circumstances—weather or sea conditions—fluctuate within a relatively wide operating range.

Moreover, when a situation initially appears to be a routine emergency, the individuals and units deployed in response are those that are used to dealing with that form of routine emergency. They bring the mindsets, training, skills, operating procedures, and experience appropriate for those situations. Thus they may not quickly recognize conditions are morphing into a different challenge.

Sometimes they may fail to perceive signs or data that do not align with their expectations because, convinced that they understand what they are facing, they are not looking for such information. In addition, responders who expect to see and deploy for a routine emergency may become highly invested in making a success of their first approach. They can be reluctant, or refuse, to perceive or admit reinforcements or different tactics are needed.

In responding to either sudden or emergent crises, the stakeholder environment is likely to become far more complex than normal. In routine emergencies, a single, specialized response organization is likely to have a well-defined lead or sole role. Political oversight is likely to be minimal and restrained unless dysfunction occurs.

In crises, the number of key actors is likely to be much larger, and the institutional lead, even when formally declared, is often ambiguous in practice. There will be many action overseers, often with too little clarity about responsibility and authority. Not only are other agencies likely to be involved in a crisis, but also other levels of government. In particularly dire situations, other nations may receive or give aid or make demands on responders.

As a result, the multiple response organizations involved in a crisis must find ways of collaborating effectively rather than overlapping, duplicating, or interfering with each other. Coordination of domestic responders and, in a severe crisis, integration of the resources of international actors is crucial. While effective coordination and collaboration are required, they may prove very difficult to achieve. A response organization is likely to share legal authorities and operate parallel to other tactical units it does not directly control. Unity of command will be an ideal that may be attained only by voluntary cooperation, not the exercise of authority.

In extended duration crises, political leaders are likely to come off the sidelines and become deeply involved, possibly bringing very different perspectives to a crisis situation than career professionals. Their viewpoints are often both more superficial but also broader than professional responders'. They typically lack expertise in emergency practices but better understand stakeholder pressures and the problems of publicly communicating, mobilizing support, and helping the community cope with loss.

Sometimes sharp tensions emerge between operational chiefs and political leaders. The latter may interfere with what operational leaders see as appropriate professional practice; the former may try to hold political leaders at arm's length even when important value choices must be made. Ideally, senior operational and political leaders will work in tandem to recognize each other's competencies, while accommodating differing perspectives and decisions and standing up for their professionals' strategic and

Crew members from U.S. Coast Guard Cutter *Harry Claiborne* observe the operation of a Vessel of Opportunity Skimming System as it collects oil from the Gulf in May 2010. VOSS is used to help remove oil from the Gulf surface. U.S. Navy photo by Petty Officer Jonathen E. Davis.

Admiral Thad Allen, National Incident Commander for the *Deepwater Horizon* oil spill, briefs the Unified Area Command in New Orleans in June 2010. U.S. Coast Guard photo by Petty Officer Ayla Kelley.

tactical viewpoints. Failure to do so can exacerbate tensions.

Moreover, in a crisis, because goals and priorities may be unclear or conflicting, there may be contention among political leaders of different levels who each have different bases of authority or represent different constituencies. This can make managing in a crisis very difficult for the professional response leaders.

Professional leadership in crises thus demands abilities and skills that are quite different from those necessary for leading in routine emergencies. Leaders must be alert for novelty that could be easily missed in an emergent crisis. They are effective not only because of their expertise and experience but to a great extent because of their ability to cope with the unexpected. Open to the realization that no one is a comprehensive expert in the face of novelty, they reach out to others who have useful expertise or varying experiences. To achieve situational awareness and generate ideas about response, leaders need to feel comfortable with a flattened organizational structure effective for drawing on information from all levels of their own organization and from very diverse sources outside. Hierarchical command may have to be relaxed not only to secure a broader perspective but also to engage many partners over whom no single leader has direct authority. Because improvised problem solutions may not work completely or at all on first try, strong leaders have to be ready to adapt their approach to find better tactics and be fault-tolerant of themselves and their subordinates.

Two Distinct Modes of Operations and Leadership

For Routine Emergencies:

- Development of contingency plans for different threats
- Professionalization of personnel through education, training, exercising
- Standardization of procedures and practices (SOPs)
- Leadership: based on authority and expertise
- Hierarchical command structure
- Precision execution

For Crises:

- Limited "scripts"; plans must be substantially adapted as the crisis develops
- Incompletely specified skill sets; no one is an expert
- Improvisation and invention required, not implementation of SOPs
- Leadership based on ability to cope with the unexpected and manage across organizational boundaries
- Variable command structure: collaborative to gather information, more directive for implementation
- Fault-tolerant execution

Graphic courtesy of authors.

Leadership in the *Deepwater Horizon* Crisis

In addition to the features of routine emergencies previously described, the *Deepwater Horizon* incident displayed many of the dilemmas of crisis leadership outlined above. Of course, the initial explosion and sinking of the oil drilling platform was a sudden crisis, but more complex dimensions of crisis emerged only gradually as the extent of the oil outflow was perceived and the difficulty of stemming it discovered.

The event presented many novelties—scale exceeding the planning frame, never-before-seen challenges, and a complex combination of emergency conditions. The dimensions of the oil spill and ongoing undersea discharge were unprecedented and extremely technically demanding to deal with. At the outset situational, awareness was very poor. The federal government overall was significantly dependent on BP, the responsible party, for information and technical expertise.

The physical environment was hostile. Technical estimates of the rate and volume of the oil leak kept increasing dramatically over the first weeks. Estimates of environmental damage burgeoned in ways that could not be reliably confirmed. The stakeholder environment was exceedingly complex, conflict-ridden, and lacked institutional communication channels suited to the novel circumstances of the crisis. This was not only a technical crisis, but impacted the three major pillars of the Gulf economy—oil, fisheries, and tourism. It also was an environmental hazard with a complicated set of legal challenges, and involved a political crisis, a Democratic president, and five Republican governors.

Coast Guard Admiral Thad Allen and his top NIC staff had to improvise in many ways to manage these pressures. As the crisis deepened, for example, the media began to question whether this was "Obama's Katrina," a severe challenge to the public welfare that the administration could be perceived as mishandling as the previous administration was seen to fail in its response to Hurricane Katrina.

Therefore, the Obama White House took an increasingly major role in monitoring how the NIC was handling not only operations but the political implications. In terms of the accountability relationships of the NIC, there was also some tension between the secretary of Homeland Security and the White House staffers representing the president, both of whom saw Admiral Allen as reporting directly to them.[5]

But other political leaders were also deeply engaged, including the five Gulf state Republican governors whose jurisdictions were experiencing the impacts of the oil spill. Several of these governors, who often had contrasting perspectives on the response and represented different local constituencies, became vocal critics of the NIC and the Obama administration.[6] Consequently, the NIC and the White House instituted daily conference calls that continued for more than three months with the five governors to raise and discuss problems and complaints. To some extent, these calls skewed what the NIC otherwise might have done, focusing it more on day-to-day issues while partially distracting it from a longer term agenda—but the calls helped defuse and contain the political pressures that could have upended the professional leadership of the NIC had it been perceived as unresponsive.

As time went by, the NIC also discovered that, as a result of the state-centric design of the Oil Pollution Act, elected leaders in the local governments along the Gulf coast felt exposed to constituent ire resulting from their lack of information and influence. Consequently, the NIC improvised

Skimming operations continue to help mitigate the effects of the BP *Deepwater Horizon* oil spill in June 2010. U.S. Coast Guard photo by Petty Officer Jaclyn Young.

a system by which individual Coast Guard officers were assigned as liaisons to specific communities.

The bureaucratic stakeholder environment of this crisis was also exceedingly complex, and the NIC leadership had to learn how to adapt and operate in this context. Several dozen federal agencies ultimately claimed legal authority over, or equity in, some aspect of the crisis. The Environmental Protection Agency was vigilant about oil spill impacts, the Food and Drug Administration focused on the effects on fisheries, and the State Department expressed concern about possible foreign affairs complications if oil drifted to Cuba's shores.

The sheer numbers of agencies and the issue density surpassed the capabilities of the White House staff as well as the NIC. Even Admiral Allen, an experienced public servant, was initially daunted by the need to deal with these diverse concerns. To cope, another institutional improvisation, the Interagency Solutions Group, was devised. The group had a number of subcommittees that met with senior NIC leaders to air issues and devise feasible solutions that the agencies could live with. This innovation helped ensure that the NIC became aware of technical and legal issues, accommodated or managed agency concerns, and kept decision making and response implementation coherent and coordinated.

This meant Admiral Allen and the NIC leadership had to strategically manage across multiple organizational, jurisdictional, sectoral, political, and international boundaries to deal with the *Deepwater Horizon* crisis. They had to overcome the initial poor situational awareness and cope with lack of political awareness on several crucial points. Because coordination among the many actors with interests at stake was often problematic, the NIC had to be highly innovative to create institutional means to make the response coherent and deal with the many emerging pressures as the response proceeded. As leaders, they had to be collaborative facilitators while problems were discovered and examined, then more authoritative, more hierarchical commanders as implementation commenced. Throughout, they could not rely only on practiced methods that were highly useful in routine emergencies. They had to be deft improvisers who could adapt repeatedly.

At the tactical level, the many Coast Guard members who were involved in this massive response had to replicate the improvisational skills of the NIC leadership to cope with the many dilemmas the *Deepwater Horizon* crisis served up.

While not flawless, the response to the *Deepwater Horizon* crisis was ultimately generally effective, thanks, in large part, to the Coast Guard.

Looking Ahead

Across the spectrum of emergencies, response organizations and their leaders must be ready for routine emergencies, as well as sudden and emergent crises. Leadership in each demands a distinctive set of skills and practices.

Routine emergencies usually prove to be the dominant challenge in number and frequency, and getting responses right for these types of anticipatable emergencies is certainly crucial and necessary for any response organization. Indeed, society benefits greatly when the range of routine emergencies is expanded—when potential crises are transformed into routine emergencies through planning, training and exercising.

But even though routine emergencies prove to be the dominant type of situation they confront, leaders of response organizations have to master a different set of skills in order to perform strongly in crises. The question for response organizations is whether leaders can become truly "ambidextrous." Will the next generation of leaders, as well as the current one, be ready to manage routine emergencies effectively but also be able to recognize novelty when it appears, manage in a different mode, prove highly adaptive, and improvise the responses necessary to deal with crises?

About the Authors

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Together, Howitt, Leonard, and Giles co-authored and co-edited Managing Crises: Responses to Large-Scale Emergencies *(CQ Press, 2009) and* Public Health Preparedness: Case Studies *(American Public Health Association, 2017).*

Endnotes:

1. This spectrum contains a continuum, not two distinct categories; but for simplicity of exposition, we shall describe them as separate categories.
2. See Herman B. "Dutch" Leonard and Arnold M. Howitt, "In Desperate Peril: High Performance in Emergency Preparation and Response," in Deborah E. Gibbons, ed., *Communicable Crises: Prevention, Response, and Recovery in the Global Arena* (Charlotte, NC: Information Age Publishing, 2007), pp. 2–25; Leonard and Howitt, "High Performance in Emergencies: Two Modes of Operation," in Howitt and Leonard, *Managing Crises: Responses to Large-Scale Emergencies* (Washington, DC: CQ Press, 2009), pp. 611–624; Leonard and Howitt, "Acting in Time against Disasters: A Comprehensive Risk Management Framework," in Howard W. Kunreuther and Michael Useem, eds., *Learning from Catastrophes: Strategies for Reaction and Response* (Upper Saddle River, NJ: Wharton School Publishing, 2010), pp. 18–40; and Leonard and Howitt, "Leading in Crisis: Reflections on the Political and Decision-Making Dimensions of Response," in Ira Helsloot, Arjen Boin, Brian Jacobs, and Louise Comfort, eds., *Mega-Crises: Understanding the Prospects, Nature, Characteristics, and the Effects of Cataclysmic Events* (Springfield, IL: Charles C. Thomas Publishing, 2012), pp. 25–34.
3. Here and throughout this paper, material about this crisis is drawn from David W. Giles, "The *Deepwater Horizon* Oil Spill: The Politics of Crisis Response (A and B)," (Cambridge, MA: Harvard Kennedy School Case Study Program, 2013), Case Numbers 1981.0 and 1982.0.
4. The perspective of novelty is subjective: "novel" means new to the people or organizations involved even if others have previously experienced it.
5. David W. Giles, "The Deepwater Horizon Oil Spill: The Politics of Crisis Response (A and B)," (Cambridge, MA: Harvard Kennedy School Case Study Program, 2013), Case Numbers 1981.0 and 1982.0.
6. Ibid.

Maintaining Response Readiness Today and Tomorrow

Ensuring Coast Guard Reserve and industry leaders are prepared

by LCDR Jonathan Bernhardt
U.S. Coast Guard Reserve and
Manager, Pipeline Compliance
Colonial Pipeline Co.

Each day, Coast Guard and maritime industry leaders must ask themselves two questions:

> *"Am* I *ready to face an unplanned incident or accident today?"*
> *"Is my* organization *ready to face an emergency?"*

What can Coast Guard and industry leaders do to feel prepared to answer such questions with confidence? Regardless of whether they are part of the government or industry, emergency response leaders know a comprehensive planning, training, and exercise program—as well as avenues to grow members into competent responders—is important, but also involves compromise.

Unified Command members (from left to right: Federal On-Scene Coordinator Captain John Little and Responsible Party Incident Commander Gerald Beck) take part in a simulated press briefing as part of the 2012 Colonial Pipeline-sponsored Industry-led Full Scale PREP Exercise in Newport News, Virginia, 2012. Colonial Pipeline photo by Steve Baker.

Leaders must prioritize preparing for an event or incident. Yes, this will take staff members away from their daily work, but for an important reason, as appropriate training can minimize incident confusion and safety threats to responders and the public.

While Coast Guard personnel and industry leaders have separate foundational doctrines and procedures, finding common ground during a response may help them act as one coordinating body and bridge any gaps to unify a response. Though leaders can never plan for all facets of an incident or event, nor anticipate when such events may happen, leaders must stay vigilant, ensure their people and organizations are ready, and confirm that new responders are getting the training and qualifications they need to take over when the time comes.

Developing Coast Guard Reserve ICS Leaders

Coast Guard Reserve leaders face an uphill battle. They must ensure the service's reserve component remains ready to face contingencies and increases in other demands at a time when the reserve force is shrinking. The Coast Guard Reserve force-strength is down to an authorized/funded level of 7,000 (actual number is approximately 6,500-7,000) from a funded high of 8,100 (authorized at 10,000) in the past 5–7 years. This is a 14 percent reduction in reserve capability and resources.[1]

Reservists must become comfortable in using the National Incident Management System-Incident Command System (NIMS-ICS), including familiarity with chain of command and unity of command, management by objectives, common terminology, and a scalable and flexible

Aboard a California Air National Guard HH-60G Pave Hawk helicopter, crew members from San Diego-based Coast Guard Maritime Safety and Security Team 91109 prepare for a fast-rope training exercise after sunset on the San Francisco Bay. Both services train around the clock in preparation to respond to situations day or night. U.S. Coast Guard photo by Petty Officer Matthew S. Masaschi.

structure. Knowledge and good execution of these ICS concepts takes training, time, and incident experience. Deficiencies in any of these areas may lead to an overall mediocre performance.

Coast Guard sector and district leaders expect their assigned reservists to augment their initial ICS response as fast as they can mobilize without lag time or additional position-specific training. Additionally, to have the right mix of Coast Guard incident management expertise and operational background, Reserve members should attain some level of "blue and green" Coast Guard foundation before attempting higher-level Incident Command System experience.[2] Unfortunately, the number of annual drills and active duty days available to each reservist for training is finite.

Donald Decker, U.S. Coast Guard Research and Development Center researcher, sets up communications equipment in Nome, Alaska, as part of the 2016 Operation Arctic Chinook mass rescue exercise. U.S. Coast Guard Photo by Lieutenant Commander Samuel Nassar.

Keeping a sense of "chronic unease," that feeling in the pit of your stomach that something unexpected could happen, is important.

Work Hard and Smart

To maximize training opportunities, leaders should ensure all members attain ICS basic training requirements as soon as practicable. This includes folding members into exercises to show how the Incident Command System is used beyond online courses or classes.

For example, many districts and sectors hold annual hurricane or oil spill exercises in conjunction with unit drilling periods and reserve personnel are encouraged to schedule their 12 days of active duty for training to take advantage of training and exercise opportunities.

Mentoring

Additionally, it can be very effective to tap full-time Incident Management Assist Team (IMAT) members as ICS coaches. IMAT members can impart their experiences and offer tips and advice to Reserve members. Further, selecting a mix of Incident Command System courses and exercises will help reservists earn ICS qualifications and raise the unit's overall readiness.

As reserve members attain higher levels of training, time, and experience in ICS, that subject matter expertise can be put to good use training the next generation of Coast Guard reservists.

Developing Industry ICS Leaders

Incident management and using the Incident Command System is not unique to the government or the Coast Guard. Maritime and maritime-related industries also must be ready to deal with unplanned incidents that will force them to respond using ICS in a unified command, as it is the proven and acceptable method to deal with incidents, and will be the response method used by any federal/state/local and tribal agencies.

While industry ICS response programs start in federal regulations, companies must decide which personnel will have to stop their day jobs and go to an emergency.

Familiarity with Coast Guard operations allows ICS responders to understand the Coast Guard's role in an interagency or whole-of-government response, and aids decisions when designing, implementing, and supporting ICS tactics.

There's No One Right Way

Some companies train toward a total in-house ICS incident or spill management team solution. Some work toward a mixed approach of half in-house and half consultant-based response. Others still rely solely on consultants to respond with only a few company members on the response to ensure the company's interests are upheld. Each company must take a hard look at its own response philosophy, staffing, and willingness to commit their employees—and their employee's own willingness to commit—to decide which model will work best for them.

Coast Guard Petty Officer Lyndsey Slabe surveys cleanup efforts after more than 5,000 gallons of crude oil leaked from a pipeline damaged during dredging operations off the coast of Bay Long, Louisiana. A unified command consisting of the Coast Guard, Louisiana Oil Spill Coordinator's Office, and ECM Maritime was established to respond to the September 2016 incident. U.S. Coast Guard photo by Petty Officer Brandon Giles.

Peer benchmarking with other like-minded companies is another aspect of ICS response for the private sector that differs from the Coast Guard or government, but also helps to increase readiness. For example, American Petroleum Institute (API) or Association of Oil Pipelines (AOPL) members often invite each other to sit down in an informal atmosphere to trade best practices and lessons learned. In addition, API holds an annual emergency response forum to learn from past responses and from local and state responders.

Working the Program

While companies may build and staff a spill management team to suit their needs, it's important to staff them with an eye toward proper initial and annual training and assigning functional leaders—such as command and general staff and unit leaders—in each ICS area. Functional leaders, usually section chiefs or staff officers, typically take ownership to ensure their unit is staffed properly, help outline training with company training or emergency response staff, and identify the next generation of ICS leaders, all in addition to their daily full-time jobs.

API's *Recommended Practices for Onshore Hazardous Liquid Pipeline Emergency Preparedness and Response (RP 1174)* offers a programmatic approach to align industry, government, and emergency response organizations' expectations, practices, and competencies to support effective incident response.

Industry drills and exercises give personnel a no-fault space to expand their training and experience. While factors such as employee time and the bottom line are critical, the ability to be trained for emergencies must also stay a core function. If the company plans in-house drills/exercises or training, all efforts should be made to invite interagency partners. This helps build knowledge and trust of one another's response procedures and personnel, and can help build an interagency network just in case an incident arises.

Succession Planning

Incident Command System succession planning in industry is also a key planning factor. Deputies and assistants will be key when the current generation of ICS leaders leaves or retires.

Company human resource managers, emergency response staff, and spill management team leads should communicate regarding probable retirements and discuss how to best plan for succession without a loss of incident knowledge. These personnel should shadow during drills and real events as much as possible to lessen the impact of key members retiring or leaving.

Rear Admiral Kurt Hinrichs, senior reserve officer, Coast Guard Pacific Area talks with members of Coast Guard Port Security Unit 301 during a tour of the Joint Logistics Over the Shore exercise in the Port of Anchorage, Alaska, in 2014. PSU 301 members, from Cape Cod, Massachusetts, are Coast Guard reservists providing port security for Department of Defense personnel and equipment during the JLOTS exercise. U.S. Coast Guard photo by Chief Petty Officer Kip Wadlow.

Looking Ahead

As a member of the Coast Guard Reserve and as an employee working daily in emergency response at a petroleum transportation/pipeline company, I believe there are more things that bring government/Coast Guard responders and industry together than there are things that divide. Using NIMS-ICS across public and private entities in the United States is a bright spot that few countries can compete with. Since large-scale industry Incident Command System adoption after the Oil Pollution Act of 1990 and widespread government adoption after September 11, 2001, the combined abilities of government and industry during an incident are a testament of working together when times call for it.

It's helpful to identify each employee's interests and skill sets when staffing ICS positions. For example, assign an extrovert or someone with public speaking skills to public information or liaison. Conversely, someone who is detail-oriented or comfortable with numbers may thrive in finance or logistics.

The near and long-term future of ICS in the American and Canadian energy revolution is also a potential growth area. As the United States becomes more energy independent, the requirements for all companies to be ready for a potential spill will also grow. More U.S. production will lead to more construction of energy infrastructure and export facilities. This is especially true in America's inland areas and waterways, where there may not be a Coast Guard nexus.

However, the Coast Guard does participate in marine industry training for active duty junior officers. Perhaps shale gas and oil revolution is an opportunity for more officers to get a better understanding of industry practices and response.

Similarly, it would be great to see industry members in emergency response, compliance, or operations work at Coast Guard units or district/area staffs in planning/exercises as a way to improve industry's response posture. As an area where there may be more ICS and response crossover, more familiarity may breed better success down the road.

Lastly, Coast Guard Reserve leaders and members should also strive to ensure the Incident Command System remains a core element of training and development. The ability of a Reserve member to immediately integrate into a response with their active duty counterparts is why ICS is the best, and most effective, way to deal with responses. Obtaining and growing in ICS position qualifications will help members be always ready.

About the author:

For 13 years, LCDR Bernhardt has served many capacities in the U.S. Coast Guard on active duty, reserve, and as a civilian. His background includes marine safety and reserve port security unit operations. He works full-time as the manager of pipeline compliance for Colonial Pipeline, headquartered in Alpharetta, Georgia.

Endnotes:

1. USCG Reserve Communications Division
2. "Blue and green" refers to Coast Guard Reserve operational areas. Blue typically includes assignment to sectors, stations, and strike teams. Green refers to port security units or CG-Navy coastal riverine forces.

Safety Afloat

It's all about culture

by Mr. Chris Fertig
General Manager
Maersk Line, Limited

Why is it that some ship crews are able to successfully complete their missions year after year without accident or mishap when those aboard ships of the same class, performing similar missions, experience multiple lost-time accidents and material damage? While many factors contribute to each accident or mishap on a ship, the single largest contributing factor to safe and successful vessel operations is the safety culture of the organization—ashore and afloat.

Forming a Safety Culture

Safety culture is a way of thinking, behaving, or working safely that permeates an organization. This results in an environment where crew members identify and take action to prevent accidents and mishaps before they occur, talk through and mitigate risks before complicated and potentially dangerous evolutions are executed, and are prepared to react to unforeseen issues when they arise.

Maersk's Army Watercraft Care of Supplies in Storage maintenance team in Yokohama, Japan. All photos courtesy of Maersk Line, Limited.

Developing a strong safety culture in any company or command must start at the very top of the organization ashore, and be tirelessly cultivated by the vessel's captain all the way down through the most junior sailor every day while underway.

How does an organization develop a strong safety culture? Shaping ways of thinking and behavior is not an easy endeavor. The following principles, tools, and processes form a foundation to develop a robust organizational safety culture:

- accountability and ownership
- organizational risk management tools
- avoiding complacency
- safety and protective equipment
- continuous process improvement

A Mine-Resistant Ambush-Protected vehicle is loaded onto the *Alliance Norfolk*.

Accountability and Ownership

This paradigm fosters an environment conducive to a high-performance safety culture. Everyone within an organization or command must be accountable and assume ownership for the safety performance of each vessel in the fleet. Organizations must ensure performance assessments, advancements and promotions, financial compensation, and retention decisions are all tied to aggressive safety performance metrics and key performance indicators.

Organizational Risk Management Tools

Organizational Risk Management (ORM) tools can help reduce and mitigate risk, as operations at sea are inherently dangerous and many daily evolutions have the potential for serious, even fatal, consequences.

Organizational Risk Management Tools

ORM: Many have heard this acronym, but what does it really mean and how does it reduce shipboard risk? The goal of organizational risk management tools is to encourage everyone to discuss the risks involved with a particular evolution, develop and review the plan for that evolution, and identify opportunities to complete the task or mission in a different way that reduces risk and ensures everyone is clear on roles, responsibilities, and emergency procedures.

Green, Amber, Red

For example, a Coast Guard crew on a medium endurance cutter preparing to launch a boarding team in the over-the-horizon small boat uses an ORM tool called the "green, amber, red" (GAR) model. This helps ensure everyone associated with the evolution is aware of all the risks and environmental and human factors involved with what they are about to execute, so they can talk through ways to reduce those risks.

Crew members ask questions like, "Did the coxswain have the mid-watch?" "Is the small boat's engine running rough?" "Is the weather predicted to deteriorate throughout the course of the mission?"

By talking through and identifying all the major risk factors associated with the evolution, it allows all the players to have input and ownership of the evolution and associated risks. Once the team identifies risks, they develop mitigation plans.

Toolbox Talk

Throughout the Maersk fleet, crews use an ORM tool called the "toolbox talk" before every evolution, including lower-level maintenance and repair activities like removing and overhauling a pump while underway. The goal is similar to that of the GAR model—review the plan for the evolution, define roles and responsibilities of all involved parties, identify all potential risks associated with the evolution, and develop risk mitigation processes and procedures to improve the overall safety of the evolution.

The key takeaway regarding these tools is to establish a culture where they are used before every evolution to get people thinking and talking about risks.

Avoiding Complacency

Complacency has injured more sailors and damaged more ships than perhaps any other single leading cause. It is human nature to develop increasing comfort levels with even the most dangerous tasks with each successful iteration, so while we may decrease our attention to detail, the risks remain constant and the chances of a mishap or accident increase.

Complacency mishaps and accidents take many forms and can be influenced by fear and adrenaline. As an example, an engineer who has just completed a night-time helo hot refueling on a stormy night is likely to be coming down off an adrenaline high. This is one of the times he or she will likely not be as vigilant as normal, so performing even a routine task in this state may be more risky than usual.

Eliminating complacency is difficult, and even the most experienced crew members are susceptible, but organizational risk management tools help to fight this shipboard safety threat. Slow down, talk through the plan, review lessons learned from similar evolutions, discuss the risks, and develop options to mitigate risks.

The Maersk *Peary*, left, conducts consolidation training at full speed with Military Sealift Command

Safety and Protective Equipment

This principle includes two important components—ensuring crews have the best safety equipment and ensuring they use that equipment to the fullest extent possible to prevent accidents and material damage.

First let's talk about safety equipment, including personal personnel protective equipment (PPE) and rescue gear. Buying the right equipment can make a significant difference in how often a particular piece of gear will be used and how well it will protect crew members, should it be put to the test.

As an example, if a seaman heads to the boatswain's locker to prepare for a day of chipping and painting, both ashore and afloat leadership needs to ensure the locker is stocked with an ample supply of comfortable, clean safety glasses. The chances the boatswain will follow company/command policy and don correct safety glasses is directly proportional to the established safety culture aboard, as well as the quality and comfort of glasses available.

One example of new PPE that Maersk Line, Limited, recently put into service is an automatically inflating life vest that includes a personal Automatic Identification System (AIS) beacon and water-activated strobes. Crew members wear these vests any time they are working in the vicinity of the side of the vessel or are out on deck at night or by themselves. These devices offer two primary safety advantages:

- These vests work automatically and will alert even if the crew member is knocked unconscious from a fall overboard.

underway replenishment oiler USNS *Rappahannock.* Photo by Garrett Long.

- The bridge watch team is immediately alerted they have a man overboard and the overboard crew member's bearing and range to the ship are displayed on the ship's electronic charting system.

Safety equipment and gear is improving every day. We must not only test, validate, and embrace these developments where appropriate, but we must also push harder for solutions to areas of maritime operations that still may have unacceptable safety records.

Continuous Process Improvement

Like ORM, continuous process improvement is another buzzword often thrown around when discussing safety. The challenge with continuous process improvement, as it relates to safety issues, is trying to prevent accidents before they occur, as opposed to learning from them.

Companies and commands with robust safety cultures tackle this challenge with aggressive near-miss reporting systems. Near-misses are leading indicators of a potential mishap or accident and occur much more frequently in the course of normal ship operations.

While safety professionals have argued specific near-miss-to-accident ratios for many years, it is generally accepted that for every accident there were many near-misses. By evaluating each one of these near-misses as they occur, ship and shore-side management can assess the issue, correct the deficiency, implement policies, deliver training, or provide better equipment to prevent future mishaps.

In organizations with a healthy safety culture, ships report near-misses in real-time and management incorporates each report into a continuous process improvement system to prevent similar issues throughout the entire fleet. For this process to function effectively, crews must feel encouraged and rewarded for highlighting potential safety issues or evolutions that could have resulted in injury or material damage.

Going Forward

Regardless of mission, the general principles of safe ship operation are more alike than they are different. How an organization establishes and cultivates a strong safety culture will determine the overarching success of the fleet and the safety of crew members and ships.

The reason afloat safety culture is so critical is that no single tool, process, principle, or person can ensure mariner safety and prevent mishaps at sea. It requires everyone within the organization to buy into, and share, an unrelenting commitment to vessel and crew safety—it's all about the culture.

About the author:

Mr. Chris Fertig is a 2001 graduate of the U.S. Coast Guard Academy and is currently a general manager at Maersk Line, Limited, responsible for vessels supporting the U.S. government.

Strategic Thinking

A culture clash in the Coast Guard

by CDR Meridena Kauffman
Office of Operating and Environmental Standards
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What challenges will the Coast Guard face in 2030, and how important will strategic thinking skills be for its future leaders as they work to meet those challenges?

In a constantly changing environment, strategic thinking is a critical skill required for leaders to keep pace with their environment. However, leaders can be so focused on crisis management that the organization may lag in development of future leaders, specifically those with strategic thinking skills.

This was revealed in the Coast Guard's own mid-grade officer leadership gap analysis. To assure strategic thinking competency in its leaders, the Coast Guard needs to institute a culture of learning as a core organizational value. Without strong strategic thinkers, the organization will constantly play catch-up in achieving its mission and will fall short of its historic motto and reputation—*Semper Paratus*—or always ready.

The Coast Guard has a well-earned reputation of being a world leader in crisis response. This is evident in our success as leaders in search and rescue, oil spill response, and countless other successes occurring every day. This dedication to the mission is bittersweet. While it ensures short-term crises are managed well, it can shortchange the future of the mission.

By spending the majority of time on day-to-day incidents and immediate demands, the long term strategies for

The Coast Guard, working closely with federal, state, and local emergency operation centers, responds to search and rescue requests in response to Hurricane Harvey in the greater Houston Metro Area in August 2017. U.S. Coast Guard photo by Petty Officer Johanna Strickland.

meaningful improvements may be delayed and never fully addressed. An easy example of this is the collection of lessons learned.

Lessons Learned

As an organization, the routine of collecting and documenting lessons learned after an incident is ingrained in routine and expected. While discussed and documented, these items are rarely tracked until completion. The reason for this seems to be because personnel are then immediately drawn into the next demand, and this becomes a higher priority in the short term. In turn, follow-up on lessons learned tends to get delayed, even though it is necessary for long-term success.

The Coast Guard helicopter has become a national symbol of rescuing those in need, and Coast Guard members pride themselves in saving lives.

This kind of environment results in people making significant decisions that impact long-term success, but making them in a short-term environment with an immediate deadline and not enough information. This tactical culture pays scant attention to the long-term consequences of current decisions and does not promote the development of future leaders with strong strategic thinking skills. Therefore, the organization will continue to be successful while never reaching full potential.

The Evolving Leadership Paradigm

The Coast Guard's ability to excel at providing service during emergencies requires a culture of flexibility and adaptability. As a result, the organization attracts and retains like-minded people. Although this state of mind has led to organizational success, it has also created a gap in cultivating strategic thinkers. A day in the life of an average mid-grade officer consists of focusing on short-term goals and solving daily problems, with little time devoted to truly considering the future of the mission and what it will take to get there.

Compounding this problematic cycle is that there is pressure at all levels for the deliverable, and even senior leadership can't always take time to realistically and thoroughly think through processes that affect an entire mission area. Many important decisions with long-term effects are made quickly, to meet short deadlines. It's easy for an organization whose success is based on its ability to rescue and respond to settle into this attitude and state of mind.

However, leadership models are changing between generations. What motivates future leaders is not always what motivates current leaders. This directly impacts organizational survival and success. Old leadership models of early selection lasting several years while climbing the corporate hierarchy yields to a new leadership model of temporary leadership that empowers employees to volunteer to lead.[1]

According to some experts, leadership is best learned in a community of like-minded people who support each other's learning in the context of real-world issues of import to both the learner and the organization in which they work.[2] Learning in a whole-person way, intellectually, emotionally, and somatically, will enhance leadership abilities. It is in this environment that a learning culture will be developed.

Coast Guard leaders need to be cognizant of the shift in value of the whole person as a resource. A rise in importance of social capital and relationships will be key determinants of business success. Accordingly, the role of human resources may become the heart of the organization—the driver of the corporate social responsibility agenda within the company.[3] This perspective clashes with existing conventional leadership models in the Coast Guard.

Cultivating Strategic Thinkers

In 2008, the Coast Guard Office of Leadership initiated a strategic needs assessment to evaluate its mid-grade officers' leadership competencies. The assessment report included information from web-based surveys, interviews, and existing data. The resulting mid-grade officer leadership gap analysis[4] includes discussion of leadership shortfalls, a root cause analysis, and recommended actions. When the current state of leadership ability, as described in the report, was compared to the optimal[5] as set forth in the Coast Guard's 28 leadership competencies,[6] significant gaps were identified. Among the top four sub-optimal skills: Strategic thinking. This short-changes the decision making process.

Illustration by Novelo/Shutterstock.com.

For example, leaders should make major decisions with the most current information and analysis, and not be influenced by decision making pitfalls like "this is the way we've always done it." Other pitfalls include overreaction, risk aversion, or being influenced only by our most recent experiences—what we did the last time this happened.

Operations specialists work together in Coast Guard Cutter *Stratton's* command center during a routine deployment. Operations specialists have assignments throughout the Coast Guard, serving primarily in command centers and aboard large cutters, participating in all aspects of operational planning and execution, working with decision makers and operators to accomplish Coast Guard missions 24 hours a day. U.S. Coast Guard photo by Petty Officer Etta Smith.

Learn From the Best

Andrew Marshall, senior policy official for the Department of Defense, is a good example of a true strategic thinker.[7] He stresses that senior defense officials must understand how to see the future. For instance, all military organizations must now make decisions based on anticipated defense and response capabilities, as it can take years to introduce a new operational concept, perfect it, and reorganize accordingly. The same goes for building leaders with strategic thinking skills.

A Learning Culture

The Coast Guard needs a culture shift. We must promote learning as a core value, and this requires a model of training and development which integrates operational and strategic thinking. Decision makers at all levels must be able to integrate the tactical needs of an individual response with more strategic concerns, and must also be able to identify and incorporate the longer-term needs of the organization, external forces and the public as a whole.

Leaders must drive responses rather than being driven by them. Through learning experiences, we can lead this change from within.

Can We Create Our Own Future?

Joseph Jaworski, author of *Synchronicity* and founder of the American Leadership Forum, says we can actually make changes when we are open to possibility.[8] Coast Guard leaders need to be able to see in terms of the future, and articulate their vision. They need to be learning leaders who pay attention, are open to possibilities, and think beyond one or two steps into the future. A learning leader who has been in tune with external environmental forces, in conjunction with coworkers, will be less vulnerable to falling into crisis management mode. They will be more likely to have a strategic perspective for routine and crisis challenges.

What challenges will the Coast Guard face in 2030 and how important will strategic thinking skills be for its future leaders as they work to meet those challenges? The answer lies in being knowledgeable about the trends, forces, and drivers affecting the world and the Coast Guard today as a way understanding what strategies are needed to deal with the future.

We need to create a learning culture. We need to challenge our traditional ways of thinking about the future, and the threats and opportunities it presents. We cannot predict the future, however, we need to make decisions based on intellectual- and fact-based forces and drivers. This will allow managers and leaders an opportunity to gain some level of control over their future situation and to transform uncertainty from a threat to a source of competitive advantage and even to shape the future.[9]

About the author:

CDR Meridena Kauffman has served in the U.S. Coast Guard for 17 years. She currently develops prevention policy in the Office of Operating and Environmental Standards.

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Leadership Lessons Learned

Early leadership experience sets stage for success

by Mr. Mike Lee
President
Terminal Security Solutions, Inc.

Underway and making way on the Grand Banks of the north Atlantic, I'm on watch as the officer of the deck of a 270-foot medium endurance Coast Guard cutter. We're operating among a fishing fleet, weaving through several dozen bottom trawlers. The sun has just set, it is icy cold and two boarding teams are deployed on our small boats.

I am conning the vessel through the fleet while keeping track of, and communicating with, both teams as they board and inspect those fishing vessels for numerous federal fisheries and safety requirements. I am flanked by my captain and operations officer, closely observing my every command and decision.

It occurs to me that at this moment I am responsible for the safe navigation of the ship, the safety of her crew, and the safe return of those boarding teams … and I am just 21 years old, and nine months out of the U.S. Coast Guard Academy.

That was 16 years ago, but those experiences, the mistakes, the life lessons, and hands-on leadership training laid the foundation upon which I have built my career. For the last 12 years, since my time as a junior officer, I've been fully entrenched in the maritime industry—more specifically, providing security and access control services to cruise and cargo terminals. Cruise terminal security in particular, presents a very unique set of challenges. For example, unlike airports, security in cruise terminals is provided by private companies—a status the cruise line industry has fought hard to maintain.

Let Me Take You on a Sea Cruise

Cruise lines, by design, set out to provide the best possible experience for their passengers from the moment they step foot in the terminal, each promoting its special brand of customer service. In the post-9/11 world, we have become very used to security procedures as a part of our daily lives and are reminded every day on the news of their necessity. But nobody likes standing in lines.

Security has always been at odds with the cruise guest experience, as it's seen as the cause of delaying the start of guests' vacations. A vast majority of cruise passengers

Illustration by Vania Tonova / Shutterstock.com.

A Coast Guard explosive-detection K-9 team prepares to transfer from the *Hornblower* cruise boat after conducting interior vessel sweeps in the San Francisco Bay. Federal, state, and local explosive-detection K-9 teams participated in a joint maritime training event that included luggage and vehicle sweeps, passenger screening, and boat familiarization. Coast Guard photo by Petty Officer Loumania Stewart

arrive at the terminal between 11 a.m. and 1:30 p.m. for a 4 or 5 p.m. departure. And with most cruise ships averaging between 3,000 and 4,500 passengers per sailing—some exceeding 6,000—that means several thousand passengers and their bags need to be processed in a two-hour window. This means lines.

The longer the line, the worse the customer experience is at the terminal, which equals poor ratings. To reduce these lines, the pressure builds to speed up the process and to be more efficient. But speed and thorough document checks, x-ray image interpretation, and passenger screening don't mix well.

Security Personnel Leadership

U.S. regulations stipulate, among other things, that 100 percent of the passengers and their effects must be screened. The job of screening for weapons, explosives and other dangerous substances is an incredible responsibility. The terminal security team is tasked with ensuring the safety and security of all the passengers aboard that ship.

But to be successful, workers must understand the delicate play between customer service that's so important to your client and the federal regulations that don't care about how customers rate their happiness with the cruise experience. This unique balancing act, coupled with keeping the work force well trained, motivated, and efficient at their jobs is a pressure cooker.

Having the right leadership personnel in place to drive the process and find that balance is of critical importance. Additionally, it has to be consistent, as every day in this business presents a new challenge. Ships are delayed, fogs roll in, x-ray machines break, personnel don't show up to work, hurricanes bear down, power goes out in the middle of an operation, passengers get upset. This is the reality of the business. Therefore leadership needs to always remain steadfast and patient to be successful.

The Fruits of Training

I was fortunate enough to have experienced navigating the pitfalls of being a leader, and making critical decisions in chaotic situations at an early age, well before entering this business. Today, thanks in large part to the training I received in the Coast Guard, I am able to apply those lessons and experiences to the direct leadership of my new terminal security company.

About the author:

A graduate of the U.S. Coast Guard Academy, former Coast Guard Lieutenant Mike Lee served as a deck watch officer on board a medium endurance cutter, conducting counter-migration and narcotics operations throughout the Caribbean. He concluded his service in Miami as a senior watch officer for the Coast Guard's District Seven Command Center, and as an intelligence officer for the Coast Guard's Maritime Intelligence Center. Mr. Lee began his civilian career as an ISPS and MTSA instructor and consultant and then as vice president of McRoberts Maritime Security for eight years prior to starting Terminal Security Solutions, Inc., in 2014. He currently serves as president of the latter.

Effective Incident Response Leadership

Today's challenges and complexities

by Mr. Ron Cantin
President
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Ms. Kirsten Trego
Executive Director
Interagency Coordinating Committee on Oil Pollution Research
Office of Marine Environmental Response Policy
U.S. Coast Guard

Mr. Kevin Sligh
Director, Response Policy National Security Council
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Office of Marine Environmental Response Policy
U.S. Coast Guard

Since 2001, disasters affecting our nation have become more complex. This means our country's emergency management community at the private, federal, state, local, and tribal levels needs to approach disasters from an all-hazards perspective.

Increased complexities demand new ways of thinking. In times of crisis, many types of leadership are demonstrated, some outstanding, most good, and unfortunately, some downright abject failures.

Most Americans point to the terrorist attacks of September 11 as a defining moment in our history that continues to influence events to this day. Since then, there have been laws, regulations, executive orders, and policies written to protect the U.S., not only from attacks, but also to better respond to the aftermath of natural and man-made disasters. Many have helped the country more effectively respond and recover from these types of events. Presidential Policy Directive-8 and Homeland Security Policy Directive-5 are the cornerstones of all-hazards mitigation, preparedness, response, and recovery efforts throughout the United States.

Complexities that now permeate all-hazard response include media engagement, politics, regulatory agency involvement, and public expectations and perceptions. Additionally, litigation, response costs, and ever-increasing stakeholder involvement in response activities also influence response effectiveness.

Senior leadership must have specific skills such as business acumen, political savvy, an in-depth understanding of the complexities of a given situation, and the ability to build coalitions, lead change, and lead effectively across the spectrum of those involved. The greatest leaders exhibit most, if not all, of those skills and qualifications.

Lessons learned and best practices arising from such disasters as September 11, Hurricane Katrina, Super Storm Sandy, *Deepwater Horizon*, the Ebola outbreaks, and public or private cyber attacks have made the country's response community realize the need to develop people capable of leading at a higher level to handle more complex disasters.

Chief Warrant Officers Leo Deon and Leonard Rich from the Coast Guard Atlantic Strike Team discuss ground zero safety strategy in New York a week after the September 11 terrorist attack. U.S. Coast Guard photo by Petty Officer Tom Sperduto.

Response Leadership Paradigms

The challenges associated with the September 11 response and recovery complexities demonstrated the need for a higher level of leadership, such as on a national level. During the September 11 response, President George W. Bush, former mayor of New York Rudy Giuliani, and the governors' of Virginia and New York broke through numerous hierarchies and many existing paradigms. In doing this, they were able to leverage organizations to lean on one another for the common good of the victims, constituents and the American population.

The attacks led to the Patriot Act, the Maritime Transportation Security Act of 2002, and the law that combined 22 federal agencies under one cabinet-level secretary to create the Department of Homeland Security. This took visionary leadership of the highest order.

Those leaders understood a key aspect of effective influence is an in-depth understanding of the entire situation. Previously, this understanding of incident complexities seldom needed to involve more than what was happening operationally—the incident location, any specific hazards to response personnel or the public, and the incident escalation

Key Incidents

During the response to the *Deepwater Horizon* incident, politicians, media, and stakeholders dominated the time and efforts of key response personnel, which necessitated delegation of many tactical considerations.

During early spring 2011, and almost 12 months into the *Deepwater Horizon* response, CAPT Julia Hein, the incident specific Federal On-Scene Commander (FOSC), was in the process of downsizing the response to a more manageable size. However, in addition to operational response goals, there remained many complexities associated with the response, such as continued media attention, public perception, local political issues, as well as planning for transition to legacy response posture, natural resource trustee concerns, demobilization of personnel and equipment, and cost documentation for the largest oil spill in U.S. history.

Complexity remained the key word. Captain Hein managed the event locally and regionally, but also internally with those responders and command post personnel still working the response at the end of the first year. What stood out the most was her capacity to use "Appreciative Inquiry" or the ability to build capacity by asking timely questions to build and foster a collaborative environment. Such environments are critical during complex catastrophes and are a hallmark of meta-leadership qualities.

In 2014, at the beginning of the U.S. government response to the Ebola virus explosion in Western Africa, the Coast Guard's Director of Incident Management and Preparedness, retired Coast Guard RADM Mary Landry collaborated with numerous federal, state and local entities to work to ensure the virus was not introduced to the U.S. via the maritime vector. Never having faced a threat similar in kind, there was a need for a novel approach to plan, prepare and execute the defense. With the threat of the epidemic transitioning to a pandemic scale, Ms. Landry and her team needed to work long hours, and closely, to provide senior levels of the government with solutions. Understanding the scale and scope of the issues at hand, she demonstrated compassion for her staff that had to work long work hours, essentially putting their personal lives on hold. She deftly communicated motivations necessary to contribute to defending the maritime environment from the Ebola virus. She demonstrated impeccable interpersonal skills that built confidence and fostered ongoing relationships across the public and private sectors showing a mastery of emotional quotient (EQ).

The Coast Guard's success of the response can be attributed to senior leadership's EQ of empathy, passion, and ability to build and maintain relationships internally and externally, thwarting the spread of the virus within the maritime domain of the United States.

The use of appreciative inquiry and EQ are two examples of skill sets within the concept of meta-leadership necessary to manage complex incidents moving forward, and should be hallmarks of what organizations use to identify future leaders within their organizations.

Coast Guard CAPT Julia Hein spoke with National Park Service officials concerning the turtle nesting areas at Pensacola, Florida, in June 2011. There was a temporary pause in Gulf cleanup efforts during turtle nesting season to ensure crews would not accidentally hit or dig up a nest and destroy the eggs. CAPT Hein served as the Federal On-Scene Coordinator (FOSC) since May 2011. U.S. Coast Guard photo by Petty Officer William Benson.

Hurricane Katrina destroyed Coast Guard Station Gulfport Mississippi. U.S. Coast Guard photo by LTJG Earl Lingerfelt.

potential. From there, incident leaders identified effective operationally oriented strategies and tactics that moved the organization toward successful incident mitigation.

Since most of the complexity focus was on factors of an operational nature, generations of response leaders grew out of an operationally oriented background and instinctively focus their attention primarily on tactical incident mitigation.

Increased Complexities, Changing Landscape

Today's complexities are substantially greater in scope. For example, persistent communication technology evolution has created an information environment that is complex, impactful, and indispensable for emergency responders, leaders, and the public.

Additionally, political winds and regulatory environments can influence decision making. The nature of these complexities varies greatly, requiring leaders to bring additional expertise into their response teams to effectively analyze and mitigate the effects. Every incident brings different levels of intensity to each of these complexities, based on the specific characteristics of the response itself, as well as different timing in terms of when these complexities peak during the incident lifecycle.

These influences are often interrelated, and can have greater effects on how a response effort is perceived than actual operational activities. Often during a response, leadership within the response organization has to address modern influences that drive the response more so than the actual tactical response activities.

Maritime Safety and Security Team 91110 patrols Boston Harbor in 2004. Created in response to the September 11 terror attacks, MSSTs have both shoreside and waterside elements for providing a blanket of security for any harbor where they are deployed. U.S. Coast Guard photo by Petty Officer Andrew Shinn.

Success = Proactive Leadership, Resiliency and Strategic Leadership

Executive Core Quals
- Business Acumen
- Leading Change
- Leading People
- Results Driven
- Building Coalitions

Complex Issues
- Media
- Recovery
- Public Perception
- Resilience
- Funding
- Politics

Emotional Quotient
- Ability to understand emotions
- Leverage to guide behaviors
- Ability to adapt to achieve goals

Key Considerations
- Communicate clearly
- Proactive engagement
- Right sizing for information management

Petty Officer Joshua Campbell, from Marine Safety Unit Cleveland, reports a capsized boat at the Emerald Necklace Marina during a damage assessment in November 2012 after Superstorm Sandy hit the Cleveland area. Along the Rocky River, the Emerald Necklace Marina was one of the many marinas in the greater Cleveland hit hard by Superstorm Sandy as it crossed the Great Lakes region. U.S. Coast Guard photo by Petty Officer Levi Read.

Meta-Leadership at the Operational Level

Leaders must think strategically for an effective response. They must translate that strategic thinking to the operational and tactical level, providing pathways to effectively manage response complexities.

Traditional staffing at an incident management team must incorporate elements necessary to today's complexities. Leaders must staff response organizations beyond just the tactical aspects of their structure. There is an ever-increasing role for public information officers and liaison officers to deal with modern complexities. Leaders must communicate clear direction and expectations and allow these trained professionals to maintain sustained, proactive issue engagement for a successful response.

Another vitally important area of staffing for success is expanded situation unit staffing. The central function is to capture, validate, package, and disseminate trusted incident information to lead efforts to mitigate effects of modern incident complexities. The situation unit must become the central source of incident-level information for professionals and decision makers at all levels of a response system.

Future Focus

A holistic approach to staffing beyond just the operationally oriented organizational elements is what will make or break a response.

Leaders need to think creatively while working with federal, state, local, tribal, and private sector partners to develop incident specific techniques.

Preparedness exercises must do a better job of drilling today's complexities, to help leaders develop high degrees of proficiency in managing them. Organizations should think about challenges and commit to specific exercise objectives that will engage participants to stretch learning and to gain experience during drills and exercises.

Recent national, state, and local administrations have provided the requisite meta-leadership necessary to address disasters and, as such, publicly traded companies have realized the need to lean forward and prepare their companies for future events due to similar complexities during a disaster.

Most notably, both public and private sectors have begun incorporating resilient measures in preparing for, responding to and recovering from disasters. One of the most critical pieces to resiliency is leadership, which is far from management by objectives during a response. Rather, it requires being able to recognize incident complexities, surround effective leaders with professionals, build coalitions, and exercise relationships.

Ultimately, based on threats affecting our nation and industries, future incidents require more strategic thinking from the onset from incident commanders than in the past. The question remains how we collectively identify future leaders and train those leaders to gain experience to address today's complex incidents.

About the authors:

Mr. Ron Cantin is president of Emergency Management Services International, Inc. (EMSI). Mr. Cantin is a 27-year Coast Guard veteran who has extensive experience in a wide range of local, regional, and national level incidents including the Deepwater Horizon *oil spill, John F. Kennedy Jr. search and recovery, Capitol Hill anthrax, typhoons in the Western Pacific, numerous other natural disasters, major maritime incidents, oil spills, national security special events, and chemical releases. He is the first person in the history of the Coast Guard to certify as a Type I Incident Commander.*

Mr. Kevin M. Sligh is currently on detail to the National Security Council as the Director of Response Policy. He is assigned as the senior technical advisor within the Office of Marine Environmental Response where he advises on all issues related to spill response for the Coast Guard. He served as deputy incident commander for the Deepwater Horizon *oil spill in the Gulf of Mexico and had previously played key leadership roles during various deployments to Hurricane Katrina from 2005-2006 and FEMA Joint Field Office deployments in support of Hurricanes Ike and Gustav in 2008. He holds a master's of business administration from Northcentral University and has been a Certified Emergency Manager (CEM) since November 2008.*

Ms. Kirsten Trego is the executive director of the Interagency Coordinating Committee on Oil Pollution Research, which coordinates a comprehensive program of oil pollution research, technology development, and demonstration among the federal agencies. Also a Commander in the Coast Guard Reserve, Ms. Trego has extensive response experience including Hurricane Sandy and the September 11 terrorist attacks, and she has served as deputy incident commander for the Deepwater Horizon *oil spill disaster.*

The Art of Persuasion

A "must-have" characteristic for success at the IMO

by LCDR Tiffany Duffy
Staff Engineer
U.S. Coast Guard

The International Maritime Organization (IMO) is a specialized United Nations organization that began operations in 1958. It is responsible for the upkeep of important international conventions ratified by its member states, like the Safety of Life at Sea (SOLAS) and its subsequent conventions.

The IMO's primary role is to maintain a regulatory framework for the shipping industry that is fair, effective, and universally adopted and implemented. These international agreements demand continuous updating to incorporate cutting edge innovations in shipping technology, lessons learned from catastrophic marine casualties, and the ever-increasing global environmental concerns.

Each member state has equal bargaining power at the IMO, and the collaborative nature of the organization requires representation with excellent bargaining skills. So it's not surprising that the U.S. government sends technical experts with a knack for negotiation and the innate ability to persuade their international counterparts on an agreeable standard for any particular topic.

It is typical at the IMO to conclude any particular biennium with a decisive strategy for improving international standards that will benefit a wide range of stakeholders in the world's maritime community. Such standards affect the acceptable levels of safety, security, and environmental sensitivity that world shipping must comply with to do business in the international commercial realm.

U.S. Influence

In perusing the organization's historic records, one will find U.S. influence in every facet of the regulatory achievements. These can be attributed to active and voluntary engagement in leadership roles during the developing stages by individuals who champion novel ideas to answer any given shipping challenge.

A sculpture of a ship's bow appears to emerge from the London headquarters of the International Maritime Organization. Photo by Bruno Mameli / Shutterstock.com.

The M/V *California Responder* simulates an oil spill 30 miles west of San Diego by releasing a non-hazardous, green dye into the water as part of a multi-agency, triennial response preparedness exercise mandated by the Oil Pollution Act of 1990. U.S. Coast Guard photo by Petty Officer Allyson E.T. Conroy.

Inclusive negotiations at the IMO require unifying leadership from those willing to lead diverse groups and the ability to sway the majority to agree on technical standards that strike the right balance between maximizing economic benefit of maritime transportation and incorporating safety, security, and clean oceans. Finding common ground on controversial issues among divergent interests in an international arena calls for a very distinct leadership trait—The art of persuasion.

Cooperation and Collaboration

Considering the cooperative and collaborative nature of the organization, leaders must emerge to align the group and to gain consensus on standards in a timely manner. Persuasive leaders are especially important when it comes to the International Maritime Organization's environmentally charged measures, as proposals on a topic are often met with concern and questions over the financial strain on the industry.

When we look back at the IMO's history, we find two prominent individuals from U.S. delegations who mastered the art of persuasion to influence the outcome of modern day environmental standard agreements at pivotal moments. The 19th Commandant of the Coast Guard, Admiral J. William Kime, and National Oceanic and Atmospheric Administration's staff legal counsel, Ms. Linda "Lindy" Johnson, epitomize the aptitude, flexibility, and finesse required to reach majority consensus on historic international standards which might have otherwise polarized maritime stakeholders worldwide.

Exxon Valdez

With the world still reeling from environmental devastation of the unprecedented *Exxon Valdez* spill in March

1989, Admiral Kime knew international parallels in vessel hull standards were imperative to fully achieve the preventive measures of the Oil Pollution Act of 1990. Having previous experience in standards development at the IMO, he liaised with the U.S. delegation to the International Conference on tanker safety and pollution prevention, and promoted the U.S.-led initiative to improve the international tanker inspection and certification system to strengthen construction and equipment standards.

It took the IMO just 11 months to adopt new standards that improved the overall safety of oil tankers and help prevent pollution from these types of ships. Admiral Kime's diplomatic persuasion successfully introduced an internationally accepted requirement for newly built double-hulled tankers that resonates today.

U.S. Coast Guard Petty Officer Billy Lemos, a pollution investigator stationed at the Incident Management Division, Honolulu, investigates a report of an undetermined amount of pollution from an unknown source causing a sheen near Pier 33 off Oahu's south shore. U.S. Coast Guard photo

Particularly Sensitive Sea Areas

By the next decade, Lindy Johnson had become a household name at the International Maritime Organization whenever there was environmental protection dialogue. As a regular member of the U.S. delegation to the Marine Environment Protection Committee, she negotiated several international agreements on some of the most arguably contentious environmental issues. Other delegations looked to Ms. Johnson in heated debates to formulate creative suggestions that could appease all stakeholders.

She engaged in leadership opportunities and chaired important working, drafting, and technical groups where details were deliberated. Ms. Johnson's signature accomplishment was designating particularly sensitive sea areas worldwide. She recognized the need for balance between the special protection of an area vulnerable to maritime activities with the benefits of global shipping, and formulated standards, processes, and guidelines to identify such areas that were scientifically based, comprehensive, and defendable. Her work on Particularly Sensitive Sea Areas (PSSA) continues to influence modern day processes for this designation.

The 19th Commandant of the Coast Guard, Admiral J. William Kime.

The History

The IMO acts on a consensus basis. If there is only a small majority from the International Maritime Organization membership that adopts any particular agreement, a significant amount of the world's shipping community could become divided. Under such conditions, it is possible that member governments could adopt their own national laws that could differ from the IMO standards. This could cause conflicting mandates for foreign-flagged vessels which deliver goods and services around the globe and must comply with requirements of the ports at which they call.

In a global economy, it remains an essential goal to harmonize national laws with international standards. From a historic and modern perspective, persuasive leadership from people like Admiral Kime and Ms. Johnson is vital to continued improvements in the world's maritime safety, security, and environmental protection.

About the author:

LCDR Tiffany Duffy, an 18-year veteran of the U.S. Coast Guard, is a marine inspector, marine casualty investigator, and led a waterway management division in the Port of Miami, Port Everglades, and the Port of Virginia. She coordinated Coast Guard interface with the International Maritime Organization at Coast Guard Headquarters from 2015 to 2017. She is currently assigned as the Chief of the Inspection Department at the Marine Safety Unit, in Portland, Oregon.

Ms. Beth Crumley, Assistant Coast Guard Historian, contributed to this article.

Integrating Science and Technology into Crisis Leadership

by Mr. Scott Lundgren
NOAA Office of Response and Restoration, Emergency Response Division
National Oceanic and Atmospheric Administration

During his confirmation testimony, Admiral Paul Zukunft was asked which lessons learned from the *Deepwater Horizon* (DWH) incident he would apply in another major disaster. His answer was the "biggest challenge during the Gulf oil spill is whole of science."[1]

While DWH was anomalous in scale, there have been a number of coastal and ocean "black swan" crises in the recent past that have warranted, and been challenged by, substantial science and technology (S&T) engagement and investigation. These include the DWH oil spill, the radioactivity leak at the Fukushima Daiichi nuclear plant in Japan, the Indian Ocean Tsunami, and the M/V *Prestige* oil spill.[2]

Certainly crises of these proportions can challenge the usual mechanisms for scientific engagement. Are there steps we can take now to improve S&T scalability engagement for future incident management and crisis response? My view is that we can, we must, and work is already underway.

The Response/Science Nexus

The scale of research investment—especially in the oil spill arena—following DWH has been very positive in leading to new discoveries and investigator interests. Coupled with these positive outcomes is a management challenge for the response organization—having numerous scientists engaged in the field previously not associated with response.

It is a critical time for leadership in engaging science in response and response preparedness. While recent events have highlighted this point in the spill response field, appropriate S&T engagement is warranted across contingencies. This challenge means incident leadership and organizations that facilitate scientific coordination must engage in advance of, as well as during, incidents.

NOAA and Science and Technology Support

The U.S. Coast Guard and the National Oceanic and Atmospheric Administration (NOAA) have a long legacy of engagement on S&T topics. NOAA is America's environmental intelligence agency, providing timely, reliable, and actionable information, based on sound science, every day to millions of Americans. This service includes support for decisions to emergency response organizations like the Coast Guard. This important collaboration helps to promote the U.S. economy, sustain our natural resources, and protect lives and property.

The Great East Japan Earthquake and tsunami caused massive destruction. Photo by mTaira / Shutterstock.com.

In addition to broad engagement across the agency, the NOAA Emergency Response Division has a 40-year history of providing scientific support, via NOAA scientific support coordinators (SSC), to Coast Guard federal on-scene coordinators during oil and chemical spill preparedness and response. This function has extended to preparedness and response to other maritime contingencies across a range of hazards including natural disasters, biological and radiological incidents, and national special security events.

Multiple drivers are at work to increase the value of, and the need for, appropriate S&T engagement and scientific support during incident response. The principal reason, also

A History of the Emergency Response Division

NOAA's Emergency Response Division (ERD) has a 40-year history of providing scientific support at spill responses, with a particular advisory role to the United States Coast Guard federal on-scene coordinator (FOSC). This role originated in December 1976 in response to the *Argo Merchant* incident near Nantucket, Massachusetts. A small oil spill research group rapidly transitioned into an operational role to help the Coast Guard FOSC address myriad scientific issues and coordinate scientists calling for involvement in the 7.7 million gallons of No. 6 fuel oil that spilled from the sinking vessel.[1] The involvement of scientists from multiple government agencies, as well as nearby ocean science institutions helped emphasize the importance of such a coordinator in helping capture and interpret the science-related issues for the response.

Steve Lehmann, scientific support coordinator from NOAA, surveys an oil spill sheen from a Coast Guard HH-60 rescue helicopter from Air Station Cape Cod. The mission of the overflight was to look for any impact from the estimated 14,700 gallons of oil released into the water when Bouchard Barge No. 120 ran aground near Long Island, New York, in 2003. U.S. Coast Guard photo by Petty Officer Matthew Belson.

The Scientific Support Coordinator

The important response concept of a scientific support coordinator (SSC) and a supporting scientific support team was of proven value, and soon thereafter incorporated into regulation as a special team under the National Contingency Plan. The National Oceanic and Atmospheric Administration (NOAA) has sustained this core function of providing scientific support during coastal zone spills. This support has expanded to the Coast Guard FOSC/sector commander/incident commander to encompass a range of scientific support across the spectrum of all hazards preparedness and incident management in the coastal zone.

While adaptable to a variety of situations, the SSC's oil and chemical preparedness and response missions remain highly relevant even in an era of celebrated prevention success. Fiscal 2017 was the busiest year in terms of raw incident numbers in ERD's history, with 205 incidents logged in our response tracking system.[2] This high number cannot be attributed to on-the-water increases in volume during the fiscal year, but is likely attributable to higher sensitivity to spills and value in the skilled support of the SSC.

Rising Demand

Moreover, the demand for SSC support is likely to rise for significant incidents, given the greatly increased domain of spill-related science as a result of the research investments made following the *Deepwater Horizon* incident. For example, in May of 2010, BP established a $500-million, 10-year independent research program, called the Gulf of Mexico Research Initiative. An equivalent value of scientific research was also conducted as part of the Natural Resource Damage Assessment,[3] and the National Academies Gulf Research Program is expected to make similar investments over the next 30 years.[4] This effort has engaged more than 1,000 scientists, 1,000 graduate students, and 255 postdoctoral students, across 42 states, 278 Academic institutions, and 18 countries. The result is 825 peer reviewed journal and chapter publications as of October 2016.[5]

This research investment has contributed to new understanding of oil fate and impacts in areas such as marine oil snow, formation of aerosols with rain, and details of microbial degraders.

While the NOAA Scientific Support Team will remain a major source of data and expertise for the SSC, this expanded scientific community will provide both new resources and scientific coordination demands in future spills.

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2. Incident counts from http://responselink.orr.noaa.gov, obtained for FY2017 on 10/5/2017.
3. www.gulfspillrestoration.noaa.gov/
4. www.nationalacademies.org/gulf/about/index.html
5. Charles Wilson, GOMRI senior scientist, October 25, 2016.

the best developed, is information is needed for response support. Incident commanders need science-based input on topics like detection and situational assessment; hazard forecasts; the potential impact to responders, the public, property, and the environment; protective advice and countermeasures; monitoring; reentry guidance; and more.

Applying results of prior scientific studies and incorporating this science into models and tools is also essential to ensuring the latest knowledge is applied to the situation. This is the most compelling science for an incident commander.

Response Research

While response professionals may be skeptical of research conducted during incidents due to potential disruptions of response efforts, if it can be accommodated without interference, it is a principal way of advancing the state of response practice. Incidents are unique situations, and providing for site or data access on a non-interference basis with appropriate safety training and procedures will allow knowledge and understanding to progress. Access and information is most compelling for science needed with direct response applicability, and this area is also most likely to be funded by the response.

However, even situations without unique compelling research needs may warrant some level of accommodation. Researchers in this situation might be compared to volunteers who wish to assist in spill response but do not meet specific response needs—a group that has been accommodated at increasing levels in recent years. I submit the approach used for volunteers—accommodating them where safe and possible—applies to the scientific community as well, especially for the portion of the community investing in planning and preparedness functions in advance.

NOAA Office of Response and Restoration staff in the Environmental Unit speak with U.S. Coast Guard staff. U.S. Coast Guard photo

There is a large science community with new understanding today, but questions on various spill related topics remain. This community will exert external pressure on a response. This expectation has the NOAA Emergency Response Division revisiting its roots with a substantial focus on models of external science coordination, in addition to maintaining our diverse group of internal spill scientists across a range of disciplines. The external science coordination function is frequently a key part of the SSC support role in larger spills, requested by the federal on-scene coordinators in incidents involving the wider science community. It is reasonable to expect increased demand for this support and need for resources to support this function during responses.

In addition to working with stakeholders to develop, test, and refine models to add structure for such engagement, NOAA's Emergency Response Division (ERD) has been further building relationships with key individual principal investigators and consortia. The parent Office of Response and Restoration also collaborates with the scientific community to ensure awareness of response matters and encourage synthesis work that addresses the needs of the practitioner during an incident.

For example, the annual Gulf of Mexico Oil Spill and Ecosystem Science Conference held in New Orleans in February 2017, encouraged researchers to consider applying their results to practical use—a theme NOAA emphasizes in its role as conference executive committee chair. The plenary session included key government leaders from the Coast Guard, NOAA, and the Bureau of Safety and Environmental Enforcement to promote thinking about research applications and synthesis.

Enhancing Reach Back for Science During Crisis Response

The Coast Guard's doctrine on Incident Management and Crisis Response, Pub 3-28, acknowledges differences between the management challenges during more routine incidents and those that rise to the level of a crisis. It also acknowledges that engagement beyond the incident response structure will likely be needed to address concerns of a broader set of stakeholders.[3]

There are similar distinctions in the science coordination required as well. The extraordinary scale and scope of the DWH incident went well beyond the traditional roles of the scientific support coordinator. The scale also warranted elevating many science coordination functions within, and beyond, the NOAA, even as the SSC structure responded at an unprecedented scale.

Further, the scope of scientific capacity engaged during massive responses, like Superstorm Sandy and other disasters, have prompted a coordinated effort to enhance science and technology reach-back capability across agencies. This effort recognizes that rapid advances in S&T availability and employment continue to change our understanding of the world and the information available in crisis.

A National Preparedness Science and Technology (NPST) task force was chartered to more fully integrate S&T into all facets of national preparedness across federal departments and agencies. This ensures such information properly informs actions in the arenas of prevention, protection, mitigation, response, and recovery. The Subcommittee on Disaster Reduction, a federal interagency body that provides a unique federal forum for scientific information sharing, was assigned to convene a task force. This task force is responsible for developing collaborative opportunities relative to national preparedness science and technology; formulate science- and technology-based guidance for policy makers; and dialogue with the U.S. policy community to advance informed strategies for managing disaster risks.[4] A subgroup is considering post-event S&T, applicability to response, and recovery mission areas. NOAA ERD has contributed to this post-incident subgroup to ensure understanding of the SSC role as a time-tested model for science coordination that can be applied beyond a specific scientific problem or discipline.

Crew members aboard Coast Guard Cutter *Healy* prepare an ice-capable oil skimmer for testing in the Arctic in July 2017. The Coast Guard Research and Development Center often deploys existing oil spill response technologies to better understand limitations and capabilities, especially in the Arctic. U.S. Coast Guard photo by Senior Chief Petty Officer Rachel Polish.

The value of a position with a role for science coordination has served the Coast Guard well for employment beyond the originating intent of the SSC for oil and chemical incidents. In addition, models for intra- and inter-agency science reach-back are being developed and documented to facilitate effective coordination of science in crisis response. Better access to such reach-back mechanisms would substantially facilitate science coordination during a crisis.

Connecting the best available science within agencies and their networks to crisis response is important, but so is ensuring this is appropriately distributed and understood within the command and coordination nodes of emergency and incident management at the federal, state, local, tribal, and territorial levels.

Strong Leadership

The science and technology domain related to incident management and crisis response—in a particular spill response—has expanded substantially in recent years, but has not yet been fully realized in a substantial incident response. This new expanded domain will exert new pressures during responses in anticipated and unexpected ways. Recognizing and embracing this new situational reality in advance, building relationships and understanding, and testing new models for engagement and coordination are important leadership roles that NOAA and the Coast Guard can play in handling this evolution driven by post-DWH research dollars.

In addition to coordinating the large population of scientists outside government and response systems, testing and refining reach-back mechanisms within and across agencies to access specialized information is also an important area of development. Collectively embracing these two activities will substantially enhance the application of the best available science and technology during incident and crisis response.

About the author:

Mr. Scott Lundgren serves as NOAA's Emergency Response Division Chief, overseeing the scientific support provided to Coast Guard Federal On-Scene Coordinators. He previously served as a Coast Guard civilian employee for 23 years, most recently as the senior technical advisor for the Office of Marine Environmental Response Policy.

Note: The views or opinions expressed herein are those of the author and do not necessarily reflect the views of NOAA or the Department of Commerce.

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3. USCG Pub 3-28 Incident Management & Crisis Response, www.uscg.mil/doctrine/CGPub/CG_Pub_3-28.pdf
4. www.sdr.gov/docs/NPST%20Task%20Force%20Charter%20FINAL.pdf

Pollution Response Planning

Re-evaluating contingency plans to mitigate potential obstacles

by LCDR Loraleigh Hild
Area Contingency Planning Project Officer
Office of Domestic Contingency Preparedness
U.S. Coast Guard

Required under the Oil Pollution Act of 1990 (OPA 90), area contingency plans (ACPs), are intended to act as the core of all domestic spill response preparedness actions. Each ACP is unique to its respective coastal area, and is maintained in each U.S. Coast Guard Captain of the Port (COTP) zone.

The president delegated authority over the inland zone to the Environmental Protection Agency (EPA) and the coastal zone to the Coast Guard. Each COTP coastal zone is required to maintain an Area Committee comprised of local subject matter experts, who are tasked with developing and maintaining their distinctive ACP. These ACPs are the centerpiece of a multi-layered, multi-jurisdictional approach to response known as the National Response System, which requires leadership at the national and local levels.

During the 19 years since the policies outlining the requirements for the individual ACP were established, the preparedness and response landscape has changed significantly. Increased risk has been introduced with the advent of the Energy Renaissance—the amplified use of rail and pipeline to transport oil-based materials—as well as drilling in the Arctic, resource reductions such as personnel dedicated to ACP formulation and maintenance, and legal vulnerabilities associated with the Endangered Species Act and historic preservation guidelines.

U.S. Coast Guard graphic by Jonathan R. Smith.

There have been several notices of intent to take legal action against the Coast Guard and the EPA over the contents of specific ACPs. The legal vulnerabilities associated with inadequate ACPs are key drivers in the Coast Guard's quest to revitalize and improve the area contingency planning process and products.

Most importantly, the *Deepwater Horizon* Incident Specific Preparedness Review highlighted shortfalls within the ACP construct. Many plans were inadequate to address small incidents, much less an incident of this scale.

The January 2011 *BP Deepwater Horizon Oil Spill Incident Specific Preparedness Review* determined the Coast Guard needed to provide direction for Area Committees to produce a standard format for all ACPs, as well as establish oversight, review, and compliance initiatives to ensure the ACPs met the requirements. During the *Deepwater Horizon* incident, the response organization was hindered by the lack of engagement of local officials, as well as a lack of knowledge of responsibilities established by the National Contingency Plan (NCP) for many responding agencies. Had the ACP development process been fine-tuned and current, many of these roadblocks could have been avoided or, at least, mitigated.

Noting the growing strength within the U.S. energy sector, the nation's position within the Arctic domain, as well as the results of the noted shortfalls of the current ACPs nationwide, the Coast Guard Office of Marine Environmental Response (CG-MER) has launched an ACP revitalization initiative. CG-MER staff completed a comprehensive assessment of the state of ACPs, and highlighted significant inconsistencies and vulnerabilities throughout the nation. The program noted improvements were needed in the overall plan content, maintaining currency, and ensuring accountability for compliance with regulations and policy. The objective of the USCG Coastal ACP revitalization initiative is to achieve service-wide consistency and compliance with respect to the NCP, OPA-90, and other established guidelines in order to maintain a standard of national readiness posture.

In establishing this initiative, CG-MER staff developed a comprehensive plan of action and milestones comprised of six major goals, defined as follows:

Establish the current status of Area Contingency Planning: Identify the status of ACP functions nationwide, thereby assisting in policy prioritization and identifying resource needs and gaps. Create a common network between national policy makers, trainers, and field planners. A recent National Response Team survey was conducted to gather input from industry, state, and local partners as well.

Achieve and maintain ACP quality and consistency nationwide in accordance with the NCP: Create new standardized contingency planning products and modernized templates, and develop more efficient processes to promote Coastal ACP quality, accountability and consistency across the nation.

Improve Area Committee participation, functionality and accountability nationwide: Develop new supporting guidelines and reporting requirements for Area Committees, reducing duplicity and increasing efficiencies while ensuring engagement with local communities, maritime industry partners and the pollution response community.

Ensure ACPs are strategically exercised and updated accordingly: Establish new protocols to ensure proper emphasis on quality scenario design and ensure subsequent plan updates adhere to established policy. Emphasis will be placed on employing a more risk-based exercise scenario selection and design. A critical aspect of this is to exercise scenarios that historically have not been done, including emerging risks, like pipeline and rail discharges.

Establish Coastal ACP common operating pictures and improve outreach: Track the status and progress of local ACPs and Area Committees to ensure compliance with the national regulations and Coast Guard policies. Refine mechanisms for more effectively communicating important information to the field.

Optimize staffing and resources: Conduct an assessment of historic and current USCG OPA 90 billets and ensure staffing is optimized accordingly and identify any gaps. CG-MER staff is seeking partnerships with industry and availability of contract support to help fill immediate needs.

To date, there are several noteworthy accomplishments towards reaching these goals. Some highlights include:

- Establishment of a Coast Guard led NRT-ACP workgroup. A first of its kind, this workgroup is tackling some critical consistency issues nationwide across the entire interagency spectrum.
- The office of Marine Environmental Response has conducted nationwide workshops throughout the Coast Guard planning and response community in an effort to promote process improvement, address gaps, and ensure the development of better quality ACPs.
- The office of Marine Environmental Response is implementing a national Coast Guard review and approval process to better ensure quality and consistency goals are met.

Coast Guard Marine Safety Unit Toledo exercise responders discuss logistical needs in response to a simulated oil spill as part of a multiagency preparedness for response exercise. U.S. Coast Guard Force Readiness Command photo

A Critical, Overarching Objective

The critical overarching objective of all ACPs is to ensure all worst case discharges from ALL facility types are identified and properly planned for. This includes discharges from geographically expansive "facilities," like pipeline and rolling stock (trains) that traverse many boundaries. A central theme of the National Response System is to ensure industry oil spill response plans (OSRPs) are aligned and synchronized with ACPs. To effectively do this, ACPs should achieve some baseline level of national consistency.

Industry partners play a large role in supporting the ACP revitalization process. The support and feedback received by individuals with perspectives unique to their trade during the process is invaluable when developing a well-rounded, complete product. Membership in an Area Committee is open to individuals representing federal, state, local, tribal, and territorial agencies or governments, and representatives from industry are considered active observers with much to contribute. Ultimately, quality ACPs require a unified effort among all industry and government plan holders across the response spectrum. As the National Response System was designed for a bottom-up, layered response approach, so too should the planning efforts.

About the Author:

LCDR Loraleigh Hild graduated from the United States Coast Guard Academy in 2003, earning a degree in management. She earned a master's in quality systems management from the National Graduate School in quality systems management with an emphasis in Homeland Security. She is currently the Area Contingency Planning Project Officer for CG-MER-2 at Coast Guard Headquarters.

In the News: Hurricane Response 2017

Hurricane Maria
Puerto Rico—September 20

Lt. Cmdr. Kelly Nolan, commanding officer of the U.S. Coast Guard Cutter *Elm,* and Petty Officer Matthew Montgomery look over relief supplies September 30, 2017, at Coast Guard Sector San Juan, Puerto Rico. The *Elm* delivered 28,000 pounds of relief supplies to Hurricane Maria victims on Puerto Rico's Vieques Island. U.S. Coast Guard photo by Petty Officer Michael De Nyse.

Understanding Alkylphenols and Alkylphenol Exothylates

by Mr. Tom Gleave
Chemical Engineer, Hazardous Materials Division
U.S. Coast Guard

What are they?

Alkylphenols (APs) are a large class of organic compounds made by the alkylation of phenols. Comprising more than 95 percent of the market, nonylphenol and, to a lesser extent, octylphenol, are the two most commercially important APs. Existing in many forms, or isomers, they are primarily used as raw materials to produce ethoxylated alkylphenols (APE) such as nonylphenol ethoxylate (NPE) and octylphenol ethoxylate.

In use for more than 50 years, APs are important to many industrial processes, and also can be found in agricultural chemicals, degreasers, paints, pesticides, personal care products, and some household cleaning products and detergents.

Physical Properties

In general, alkylphenols are clear to pale viscous liquids that have low vapor pressures and exhibit a slight phenolic odor. They are chemically stable under normal temperatures and pressures and do not adversely react with water. APs are soluble in alcohol, but only moderately water soluble.

Ethoxylated alkylphenols, on the other hand, are clear to light-orange oily liquids or waxy solids, and are considered chemically stable and unreactive. They exhibit a "water attracting" property at one end and a "water avoiding" property at the other end of the molecule, making them useful in surfactant and detergent applications.

Risk Factors

The toxicity of APs and APEs vary, with a larger alkyl group like octyl-, nonyl-, and dodecylphenol being the most toxic.

➤ *Human Health Concerns*

APs have been detected in bodily fluids, and are associated with reproductive and developmental effects in rodents. Octylphenol ethoxylates are listed as hormone- and endocrine-disrupting chemicals in the European Union, where they are no longer produced. The United States is voluntarily phasing out NPEs from industrial laundry detergents.

➤ *Environmental Concerns*

APs are not readily biodegradable in the aquatic environment, are extremely toxic to fish and other water-dwelling organisms, and have been shown to cause long-term adverse effects. Bioconcentration is significant in water-dwelling organisms and birds, where it has been found in concentrations between 10 and 1000 times greater than the surrounding environment. NPEs are also highly toxic to aquatic organisms, and degrade to nonylphenol in the environment.

What is the Coast Guard doing about it?

APs and APEs are assigned to Compatibility Group 21, *Phenols, Cresols,* in 46 CFR Part 150. Many APs and APEs can be shipped in bulk domestically in accordance with 46 CFR Subchapters D and O, and internationally as products under the several IBC code entries like Alkylated (C4-C9) hindered phenols, Alkyl (C7-C11) phenol poly(4-12) ethoxylate, Alkyl (C9-C15) phenyl propoxylate, Nonylphenol, and Nonylphenol poly(4+) ethoxylate.

The IBC Code and 46 CFR Parts 151 and 153 assign carriage requirements like ship type, pollution category, and other requirements specific to each product or cargo. Among these requirements is specified tank type, vent, and environmental control, and whether emergency equipment is required. There may also be certain special requirements for products determined to be toxic. Carriage requirements for APs and APEs vary with toxicity and pollution characteristics.

For unassessed products and mixtures, including APs and APEs not found in the regulations or IBC Code, CFRs or the IBC Code contains classifying procedures based on the type and intended type of transport. Products to be carried on U.S. inland tank barges are classified under 46 CFR 151, while products to be carried on U.S.-flagged tank vessels operating domestically are classified under 46 CFR 153. Products shipping internationally are assessed and classified using Tripartite Agreements under the IBC Code and the Guidelines for the Provisional Assessment of Liquid Substances Transported in Bulk.

About the author:

Mr. Tom Gleave is a chemical engineer in the Hazardous Materials Division at U.S. Coast Guard headquarters. He earned a B.S. in environmental engineering from Temple University and has more than a decade of experience in the field. He also served four years in the U.S. Navy as an aviation electricians' mate.

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Nautical Engineering Queries

Questions

Prepared by NMC Engineering Examination Team

1. If an induction motor were to be operated at 90% rated voltage and at rated load, what would be the result?

A. There would be an increase in starting torque.
B. Starting current would increase slightly.
C. Synchronous speed would decrease slightly.
D. Running current would increase and the motor would run hotter.

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2. A hydraulic system directional control valve fitted with "detent" will ____________________.

A. have an infinite number of valve positions
B. usually be shifted into three specific positions
C. be able to be varied throughout the travel of the valve spool
D. have an offset, directional control only

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3. Diesel engine cylinder head test cocks are used to ____________________.

A. check cylinder lubrication
B. connect the pressure indicator
C. pressure test cylinder heads
D. connect the exhaust gas pyrometers

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4. Scavenging air is supplied to steam soot blower elements to ____________________.

A. prevent backup of combustion gases into soot blower heads
B. provide cooling air when soot blower elements are rotating through blowing arcs
C. prevent buildup of soot on the element
D. prevent overheating of adjacent tubing

Nautical Deck Queries

Prepared by NMC Deck Examination Team

Questions

1. **INLAND ONLY: What lights are required for a single barge being towed alongside?**

   A. sidelights and a stern light
   B. sidelights, a special flashing light, and a stern light
   C. sidelights and a special flashing light
   D. sidelights, a towing light, and a stern light

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2. **What is the displacement of a barge which measures 85′ x 46′ x 13′ and is floating in salt water with a draft of ten feet?**

   A. 1117 tons
   B. 1452 tons
   C. 500 tons
   D. 17.5 tons

---

3. **Hoses used for cargo transfer operations must be tested and inspected at specified intervals by whom?**

   A. a representative of the Captain of the Port
   B. the operator of the vessel or facility
   C. a representative of the National Cargo Bureau
   D. a representative of the American Bureau of Shipping

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4. **What occurs when rising air cools to the dew point?**

   A. Advection fog forms.
   B. Humidity decreases.
   C. Winds increase.
   D. Clouds form.

1. *Note: For a motor operating at its rated load, it is important that it also be operated at its rated voltage. Torque, current, speed, and operating temperature can all be impacted by operating at a voltage other than the design, rated voltage.*

A.	There would be an increase in starting torque.	Incorrect answer. The starting torque and current (also known as the locked rotor torque and current) of an induction motor increase with increasing applied voltage. A lower-than-rated applied voltage, therefore, would cause a decrease in starting torque (and starting current).
B.	Starting current would increase slightly.	Incorrect answer. As explained in choice "A" above, a lower-than-rated applied voltage would cause a decrease in starting current (and starting torque).
C.	Synchronous speed would decrease slightly.	Incorrect answer. The synchronous speed of an induction motor is dependent on the frequency of the supply voltage and the number of poles in the stator winding, which both determine the speed of the rotating flux. As long as the frequency of the supply voltage is delivered at the motor-rated frequency, the low voltage would not cause the synchronous speed to decrease.
D.	Running current would increase and the motor would run hotter.	**Correct answer.** The running current and slip of an induction motor decrease with increasing applied voltage. A lower-than-rated applied voltage, therefore, would cause an increase in running current, which would cause the motor to run hotter.

2. *Note: A directional control valve fitted with "detent" is typically manually operated by means of a lever. When the lever is moved to a specific valve position, the detent allows the operator to let go of the lever and the valve will remain in that position.*

A.	have an infinite number of valve positions	Incorrect answer. If a directional control valve is fitted with "detent," it will have a finite number of positions (typically three), not an infinite number of positions.
B.	usually be shifted into three specific positions	**Correct answer.** With the lever positioned in the upright position, the valve is held in the center position by the center position detent. The other two positions (for example, "up" and "down") are associated with moving the lever to the maximum travel in either direction from the center, to be held in the "up" or "down" position detents as appropriate, giving a total of three valve positions.
C.	be able to be varied throughout the travel of the valve spool	Incorrect answer. If the directional control valve has three detents (which is typical), the valve will only have three positions at which it can be held and not varied throughout the travel of the valve spool.
D.	have an offset, directional control only	Incorrect answer. If the directional control valve has an offset spring, the valve will typically have two positions, and instead of having detent, as soon as the valve lever is released, the valve spool will automatically shift to the offset position.

3. *Note: While diesel engine cylinder head test cocks may be used to remove moisture accumulations from the cylinders prior to starting, as the name implies, the primary function of the cylinder head test cocks is to provide a place of attachment for a cylinder pressure indicating device.*

A.	check cylinder lubrication	Incorrect answer. Where fitted, cylinder lubrication is checked by observing cylinder lubricator pump sight-flow glasses.
B.	connect the pressure indicator	**Correct answer.** The cylinder head test cocks (also known as indicator cocks) are used as a place for attachment of cylinder pressure indicating devices for the purpose of measuring cylinder compression pressure, cylinder firing pressure, or cylinder performance.
C.	pressure test cylinder heads	Incorrect answer. Pressure testing of cylinder heads is done to evaluate the integrity of the cooling water jackets, checking for cracks and leaking gaskets.
D.	connect the exhaust gas pyrometers	Incorrect answer. Exhaust gas pyrometer thermocouple probes are permanently installed in strategically located exhaust gas passages.

4. *Note: Scavenging air from the windbox of a boiler is used to cool the soot blower element and to prevent the backup of combustion gases into the soot blower head when not actively blowing tubes.*

A.	prevent backup of combustion gases into soot blower heads	**Correct answer.** As explained in the note above, the scavenging air prevents the backup of combustion gases into the soot blower head (when not actively blowing tubes).
B.	provide cooling air when soot blower elements are rotating through blowing arcs	Incorrect answer. Although scavenging air does provide a cooling function, it is when tubes are not actively being blown—not when rotating through blowing arcs.
C.	prevent buildup of soot on the element	Incorrect answer. Scavenging air has no impact on soot buildup on the element.
D.	prevent overheating of adjacent tubing	Incorrect answer. Although scavenging air does provide a cooling function when tubes are not actively being blown, this air has no impact on the temperature of adjacent tubing.

1.	A. sidelights and a stern light	Incorrect answer.
	B. sidelights, a special flashing light, and a stern light	**Correct answer.** Reference Inland Rule 24 (f)(ii). Inland Rule 24 (f)(ii) states: *"(ii) A vessel being towed alongside shall exhibit a sternlight and at the forward end, sidelights and a special flashing light."*
	C. sidelights and a special flashing light	Incorrect answer.
	D. sidelights, a towing light, and a stern light	Incorrect answer.

2.	A. 1117 tons	**Correct answer.** Reference *Modern Ships,* John H. La Dage, Second Edition, page 262. Displacement = (Length × Breadth × Draft) ÷ 35 Displacement = (85 × 46 × 10) ÷ 35 Displacement = 1117.1 tons
	B. 1452 tons	Incorrect answer.
	C. 500 tons	Incorrect answer.
	D. 17.5 tons	Incorrect answer.

3.	A. a representative of the Captain of the Port	Incorrect answer.
	B. the operator of the vessel or facility	**Correct answer.** Reference 33 CFR 156.170(a). 33 CFR 156.170 states: *"(a) Except as provided in paragraph (d) of this section, no person may use any equipment listed in paragraph (c) of this section for transfer operations unless the vessel or facility operator, as appropriate, tests and inspects the equipment in accordance with paragraphs (b), (c), and (f) of this section and the equipment is in the condition specified in paragraph (c) of this section."*
	C. a representative of the National Cargo Bureau	Incorrect answer.
	D. a representative of the American Bureau of Shipping	Incorrect answer.

4.	A. Advection fog forms.	Incorrect answer.
	B. Humidity decreases.	Incorrect answer.
	C. Winds increase.	Incorrect answer.
	D. Clouds form.	**Correct answer.** Reference *Modern Marine Weather,* David Burch, First Edition, page 58. Warm, moist air that is rising eventually cools to the dew point of the air, at which time it condenses onto dust and other particulates to form clouds.

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