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MARITIME RISK SYMPOSIUM

2020

REPORT 2020

REPORT 2020:

11TH ANNUAL MARITIME RISK SYMPOSIUM

Understanding and Managing Risks to the Marine Transportation System

HELD VIRTUALLY, OCTOBER 26–30, 2020

Hosted by the Critical Infrastructure Resilience Institute (CIRI), a Department of Homeland Security Center of Excellence at the University of Illinois Urbana-Champaign

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2020 – Department of Homeland Security Center of Excellence: Critical Infrastructure Resilience Institute, University of Illinois Urbana-Champaign

2019 – Maritime College, State University of New York, Bronx NY

2018 – Oak Ridge National Laboratory, Oak Ridge Tennessee

2017 – The Center for Cyber Defense & Forensics at Tiffin University, Tiffin Ohio

2016 – Department of Homeland Security Center of Excellence: Coastal Resilience Center (CRC), the University of North Carolina at Chapel Hill

2015 – Department of Homeland Security Center of Excellence: Maritime Security Center (MSC), Stevens Institute of Technology

2013 – Department of Homeland Security Center of Excellence: Visual Analytics for Command, Control, and Interoperability Environments (VACCINE), Purdue University

2014 – Department of Homeland Security Center of Excellence: Center for Risk and Economic Analysis of Terrorism Events (CREATE), University of Southern California

2012 – Department of Homeland Security Center of Excellence: Center for Risk and Economic Analysis of Terrorism Events (CREATE), University of Southern California

2011 – Department of Homeland Security Center of Excellence: Command, Control, and Interoperability Center for Advanced Data Analysis, Rutgers University

2010 – Department of Homeland Security Center of Excellence: Center for Risk and Economic Analysis of Terrorism Events (CREATE), University of Southern California

The 2021 Maritime Risk Symposium will be hosted by the University of Houston, November 2–4, 2021. https://www.maritimerisksymposium.org/

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INTRODUCTION

The Critical Infrastructure Resilience Institute (CIRI) conducts research and education that enhances the resiliency of the nation's critical infrastructures and the businesses and public entities that own and operate those assets and systems. CIRI is funded by a $20 million, five-year grant from the Department of Homeland Security. It is led by the University of Illinois Urbana-Champaign with collaborators from other US universities and national labs. With an emphasis on outputs-oriented research, education and workforce development, and early and continuous engagement with end users and homeland security practitioners, CIRI explores the organizational, policy, business, and technical dimensions of critical infrastructure's dependence on cyber assets. CIRI examines how computer hardware and software both contribute to and threaten resiliency and how industry makes decisions about cyber assets that contribute to resilience. A significant focus of CIRI is on transitioning research outputs for use by DHS operational components, other homeland security end users, policymakers, decision-makers across all levels of industry and government, and community leaders.

KEYNOTE ADDRESS: "THE RESILIENCE IMPERATIVE," DR. STEPHEN FLYNN

Summary of Key Points

The theme of Dr. Flynn's address was the "resilience imperative," which he hopes will increasingly inform how we think about and manage risk within the maritime realm.

There aren't necessarily more threats and hazards today than in the past; there have always been disruptive threats and hazards. The thing that's new, which forces us to put resilience front and center, is that we have become hyper-connected to achieve efficiency. Every time we make a connection, we create a dependency, and when we make multiple connections, we generate interdependencies; and those imply built-in fragility. Today, when something happens that in the past would have been a localized shock, it may now cascade in far more disruptive and destructive ways. The impact of a single well-placed bomb could be extremely widespread. What used to be local can now become global.

Resilience is not just what you do *after* "something goes bump in the night," but about how you *prepare* for changing conditions. We want to design things to

withstand disruption, and when disruptions happen, we want to adapt to the reality as well as recover rapidly.

Point 1:

Five substantial barriers are keeping us from becoming resilient. To put resilience in the practice, we must work on overcoming them. They are:

1. Risk illiteracy and pervasive lack of understanding of interdependent systems. Lack of trust in and understanding of science is undermining a foundational element of building resilience.
2. Inadequate designs for embedding resilience into systems at multiple levels. We design things for efficiency, not for resilience.
3. Pervasive economic disincentives for investing in resilience, because it may be seen as raising costs, at least in the short term.
4. Inadequate governance frameworks and policy guidance to foster resilience. The issue of interdependency across sectors and jurisdictions is a nightmare from a bureaucratic standpoint. The private/public mix adds to that and affects our ability to come up with a comprehensive system of systems solutions.
5. Lack of adequate training and education on resilience to support the development and implementation of tools, applications, processes, and policies.

Point 2:

When it comes to putting resilience into practice, we should think about it as a resilience cycle. Resilience measures need to be incorporated into managing the risk of community disruption (1) prior to, (2) during, and (3) following a disaster. And when we're recovering, we don't just want to bounce back, we want to bounce forward; we want to adapt our approach based on what has happened to feed back into better preparation. It's an ongoing process.

Point 3:

The stepping off point for establishing resilience priorities is to identify three things for our infrastructure, systems, and networks: (1) the *elemental capacity* (the system conditions that must be in place in order for an infrastructure, system, or network to provide its function to its users), (2) the *essential function* (the minimal level of function an infrastructure, system, or network must provide to meet the critical needs of its users and support recovery), and (2) *full/normal function* (what an infrastructure, system, or network provides to satisfy the routine needs of its users and to remain economically viable).

Point 4:

We can think in terms of five resilience attributes. Collectively, our goal should be to develop these attributes to allow us to deal with disruptions with the least possible loss of function and the quickest recovery:

- *Cushionability*: The capacity to support graceful degradation of nonessential function during periods of stress.
- *Resistance*: Measures that redirect a threat of hazard away from where it can cause damage to elemental capacity or disrupt essential function.
- *Robustness*: Measures that harden or protect elemental capacity and essential function.
- *Redundancy*: Back-up systems or spare components to support immediate recovery of elemental capacity and essential function.
- *Adaptiveness*: Capacity to adapt to surprises and uncertainty associated with the future risk environment. It means designing things to fail gracefully and have a regenerative ability to come back.

Point 5:

Before a disaster occurs, we can develop models and conduct simulations to raise awareness and understanding of the potential for system disruption and its consequences; support "what-if" decisions, including cost-benefit analysis for investing in resilience design; inform contingency planning; identify resilience attributes to deploy to safeguard and rapidly recover elemental capacity and the essential function; devise incentives for making sustainable investments in the attributes of resilience design; and deploy tools and processes that provide situational awareness for early detection and guide nimble response and recovery when there are disruptions to elemental capacity and function.

Following a disaster, our goal is to direct limited resources to support response, recovery, and adaptation. We would prioritize actions that restore elemental capacity and essential function and undertake actions that restore full/normal function. We would learn from the event; what can it tell us about how to improve the design and deployment of resilience attributes, and refine the operational measures used to support response and recovery?

Point 6:

Resilience offers a competitive advantage. People and companies that have a choice will choose to live and invest in those communities and enterprises that are resilient, and abandon those that are not. We can incorporate resilience into economic development by blending development priorities with resilience

imperatives; adapting codes and incentives to support innovative resilience designs; and teaming planners and regional developers with emergency managers.

To advance maritime infrastructure resilience, we much accomplish 3 things at the same time: (1) conduct research that informs infrastructure resilience and community resilience; (2) support early and widespread adoption of resilience applications, tools, and protocols by establishing best practices, standards, and codes; and (3) identify and deploy public policy and market-based incentives for adopting infrastructure and community resilience best practices.

Takeaway:

- Resilience requires deep understanding of hazards and risks across infrastructure sectors at the community and regional levels.
- Companies and communities need to "bake" resilience into their critical systems and functions.
- Large-scale disasters are always regional and multi-sectoral, requiring robust cross-industry and cross-jurisdictional collaboration.
- Resilience is increasingly a competitiveness issue.

PANEL #1: RESILIENCE IN MARITIME INFRASTRUCTURE

Moderator/Chair: Capt. Todd Bonnar (Branch Head, Combined Joint Operations from the Sea Centre of Excellence (CJOS COE))

Panelists: Mr. Rob Cannizzaro, Dr. Rob Huebert, Mr. Richard Perks, Mr. Carl Wrede

Panel Abstract:

It is indisputable that the world's economy floats on seawater. It is equally indisputable that international maritime transportation and the infrastructure that supports it is the tool that keeps the global economy moving. The world economy has surged over the last half century, and that growth has been largely driven by globalization and the consequent reduction in barriers to trade. The maritime transportation sector's symbiotic relationship with the global economic system means that the risks faced by the maritime industry are often second and third order, influenced by factors often not identified as risk, and beyond its control. As Martin Luther King, Jr. said, "Lightning makes no sound until it strikes."

Disruptions due to a lack of resiliency in maritime transportation infrastructure have wider consequences for society, making the management of the associated risks a priority that should transcend industry and national security boundaries. Clearly, an increasingly connected world requires a resilient maritime community able to withstand an unanticipated lightning strike from the many interconnected risks in the maritime commons. Disruptions due to a lack of resiliency in maritime transportation have wider consequences for society, making the management of the associated risks a priority that should transcend industry and national boundaries.

Mr. Carl Wrede (DLR Institute for Protection of Maritime Infrastructures, Germany), Panelist:

How prepared are we for major shocks to maritime infrastructure systems, and has COVID-19 highlighted where we need to improve resiliency? How successful are we in anticipating risks, avoiding losses, reacting to crises, and recovering from disturbances?

In fact, we don't seem to be getting better at foreseeing and preparing to deal with catastrophic events. We may adapt to current risks only to have the risks disappear or become less important. It's hard to stay on top of that game; investments made may be in the wrong area. The underlying challenge comes down to: we never know what risks we will actually have to deal with.

Vulnerability of critical infrastructures is a growing national concern, and it's easier to know your infrastructure than it is to know the risks you're facing. However, if we look at the national infrastructure system, it is not one infrastructure, but a global system of infrastructures that are highly dependent on each other and connected to each other. You can't think of a port as a single infrastructure; you have to think of the port as the means for transport in a global logistic chain. And that, again, makes it very challenging to understand what is the infrastructure that we are concerned about.

It is necessary to understand that the maritime infrastructure system is a globally connected system; focusing just on a single port, a single country, or a single type of vessel gives a false impression. Second, shipping is affected by global crises, simply because it is a global means of transport.

Mr. Rob Cannizzaro (Port of Virginia), Panelist:

Mr. Cannizzaro works at the Port of Virginia, a business entity of the Virginia Port Authority. In his presentation, he described the Port and its resilience strategies.

He began by detailing some of the Port's facilities.

He then explained that while there are many aspects to successful operation, the three most critical requirements are for the port to have people, power, and systems. Even in a semiautomated environment, people are required to manage systems and processes, remotely operate cranes responsible for vertical transport, and physically operate all vehicles that are not automated. Most importantly, people are responsible for maintaining the systems and machinery that move containers on the terminal.

Resiliency comes from preparation and redundancy. For power, we have redundancies that include independent transformers capable of supplying the terminal load in its entirety, building the network backup generators, and terminal infrastructure that can be powered by independent generators. For IT, we have on-premises data centers with constant cloud backup, two separate power feeds to each of our redundant servers, rack, and data center, UPS or uninterruptible power supply, constant remote monitoring, and failover alerts with remote access resiliency. While many other elements are included in our resiliency plans, like our Maritime Incident Response Team, and our close collaboration with the US Coast

Guard and other maritime stakeholders through the Virginia Maritime Association, the Port of Virginia is resilient and prepared for threats that could limit its ability to facilitate commerce.

Dr. Rob Huebert (University of Calgary), Panelist:

Dr. Huebert talked specifically about resilience in the North American Arctic and whether COVID has had significant impact there. He noted that in Arctic operations, some unique factors set the region apart from others in terms of resilience: long distances, lack of infrastructure, ice and other weather conditions (with the extent of sea ice varying dramatically through the seasonal cycle), and the fact that maritime traffic consists of nuclear submarines, icebreakers, and a small number of ice-strengthened surface vessels; nothing else can get through in the Arctic conditions.

Notably, most of the Arctic ice is on the North American side, and the greatest amount of opening is on the Russian side; and, unsurprisingly, there is a substantial buildup of infrastructure on the Russian side.

Operation Nanook in August 2020 was the largest maritime cooperative exercise that has been performed. One finding was that thin-skinned vessels could go into the Arctic when there was almost no ice (i.e., August). There was no problem with COVID isolation, because there are no ports where a vessel could stop and come into contact with the virus. But there was a realization that if a COVID outbreak had occurred, it would have been very difficult to offload people to a place with medical infrastructure.

The May 2020 voyage of the *Kiwi Roa*, a sailing vessel from New Zealand, presented another challenge. Canada claims the Northwest Passage as internal waters, on which pleasure vessels were not allowed because of COVID. The *Kiwi Roa*'s owner claimed that the Northwest Passage is territorial waters. The situation illustrated the difficulty of even tracking a vessel, which in fact got all the way to Cambridge Bay. It called attention to the problem of how Canada can maintain control in this region in the future.

Finally, the temporary loss of the USCG icebreaker Healy, following a fire in its engine compartment, represented a major loss of overall American surface capability in the Arctic, and illustrated US and Canadian vulnerabilities. The US really has no functioning icebreakers now; the loss of one vessel had a major impact.

COVID has had limited impact on the maritime Arctic, but it could have been a major crisis for Canada if we had had an outbreak on a ship. When we talk about

resilience in the Arctic, we mean resilience in a place where simple survival is a challenge even at the best of times.

Mr. Richard Perks (NATO Allied Command Transformation Headquarters), Panelist:

Mr. Perks began by stating that he would speak from a NATO perspective (although his expressed views were his own and unofficial).

NATO is a political military alliance of 30 European and North American allies, each of which retains national responsibility for its own security. They work together for the collective security and defense of the alliance, so in the event of an armed attack against one ally, all allies commit to the defense of that ally. Thus, resilience in the NATO context is a national priority. The challenge in NATO is in connecting and supporting 30 national resilience plans with a broader resilience plan.

The greatest responsibility of the Alliance is the protection of its populations and its territories from aggression. The maritime domain is fundamental to that; an ally's ability to reinforce other allies is heavily dependent on the maritime domain. In particular, in the Atlantic, *SLOCs* (strategic lines of communication) are essential to connecting North American and European allies.

Ownership of maritime infrastructure is an important factor as we think about maritime resilience. It is necessary to coordinate across various operational domains and across civilian areas—the political, economic, sociocultural areas—in an environment that is highly competitive. For example, we are at war today in the cyber domain, while at the same time, we're cooperating on trade and global logistics with some of those same actors with which we're at war! Cooperation, fighting, contesting, and shaping the environment are all happening simultaneously. That's an important challenge with respect to resilience.

Allies' forces must use or are impacted by civilian infrastructure, civilian ocean transport, ports and port infrastructure, logistics chains, satellites, and navigation and identification systems. Ocean transport could be either government-owned, or privately owned; civilian communications links, including undersea cables, might be utilized.

Resilience of all this infrastructure is essential and is increasingly a key aspect of military planning—and it's starting to change military planning. Mr. Perks is involved in the development of the NATO Warfighting Capstone Concept, focusing on how we develop our military instrument to win in this evolving battlespace. More and more, the operational commanders are raising the notion of *resilience*. Resilience is fundamental to our ability to fight and win.

Layered resilience is one of the key imperatives being put forward. It has three layers: a military layer, a layer of civilian support for military resilience (such as ocean transport and undersea cables), and a layer of military support for civilian preparedness and resilience. An example of that third layer is the military efforts towards COVID-19 response; but we need to guard against the potential for military overstretch. We are still learning from the pandemic. Strategic military competition for advantage does not stop for a pandemic. A pandemic increases instability in the world: it amplifies misinformation, and it can impact trust in our institutions. It challenges civilian and military preparedness and our supply chains. Most importantly, it reveals vulnerabilities and weaknesses, especially to competitors.

So, are we prepared? We're moving in the right direction. We've got the right ideas on the table. We're having the right conversations in the alliance, but we have a lot of work to do. Arguably, improving resilience must be embraced as a perpetual task.

In conclusion, Mr. Perks offered his opinion is that an important area in which we need to improve is in recognizing the importance of improved and habitual connectivity across the instruments of power. Relationships need to be continually developed, and our overall resilience will be measured by the strength of that connective tissue. So that's an important area for us to focus on: connectivity and the resilience of the whole as well as the individual parts.

Takeaway:

There's an interconnectedness and a systems approach to everything, whether it's supply chain, whether its operations, whether it's planning for military operations. When you have these interdependent and interconnected networks, you don't control every aspect yourself; everything is interrelated. So you need to have communication, and you need to have trust.

Three main points from our panel are as follows. (1) Resilience must happen in layers. (2) These layers require thorough stakeholder mapping and engagement. (3) Isolation (as per Dr. Rob Huebert's presentation about the Arctic) is not always a negative when we're talking about resilience.

PANEL #2: MARITIME RESILIENCE AND THE HUMAN ELEMENT

Moderator/Chair: Capt. David Moskoff (Professor and USCG Unlimited Master Mariner, US Merchant Marine Academy)

Panelists: Mr. James Scalli, Dr. Michael Benjamin, Mr. John Jorgensen

Panel Abstract:

Has the age of maritime discovery and exploration ended? Perhaps not exactly. As the history of maritime resilience and the human element shows, as far back as the 1500s, from using new navigational aids and improved ship designs, to coastal and inland route sailing, to navigating on open seas with uncertain charts, wayward icebergs, dense fog, and, at times, luckily, clear starry nights, mariners have faced human element and maritime resiliency challenges. "Short of food and water, the sailors ate sawdust mixed with ship's biscuits and chewed the leather parts of their gear to keep themselves alive."[1] Not surprisingly, human resilience has almost always been the key that determines success or failure of maritime enterprises.

This panel inspires us to learn about and train for dealing with the actual and many-fathom-deep significance of human resilience in the 21st century maritime environment.

Mr. James Scalli (Manager Maritime Assurance, Vessel Quality Assurance - Americas at Shell Trading), Panelist:

Mr. Scalli spoke on the topic of human resilience in maritime operations and included an overview of Shell Shipping & Maritime's operations and its Maritime Partners in Safety program.

The Maritime Partners in Safety program was established after concerns emerged in 2011 that there were too many incidents or potential incidents across Shell operations. It involves not just Shell but all the companies across the globe with which Shell engages. Three primary pillars of the program were identified, as

[1] Jean Brown Mitchell. "European exploration." Encyclopedia Britannica. Encyclopedia Britannica, Inc., May 30, 2018. https://www.britannica.com/topic/European-exploration

follows. (1) Good-quality periodic leadership visits by the CEO, going on board vessels and interacting with the crews. (2) Reflective learning in response to things that have been trending in incidents. If you just read something to people, there's limited retention; if you talk with people about it, it makes a big difference. (3) Learning from incidents, which is a bit like reflective learning but involves small groups of people talking about smaller relevant items.

That worked well, and a threefold improvement was observed in the years after this program was established; but we then plateaued, with no further significant improvement. In response, the decision was made to add the concept of "resilience" as the foundation underlying all three existing pillars of the program.

What is resilience? It's the ability to cope with pressure and stressful events. It's a quality worth developing to enhance the ability to manage increasingly complex and busy lives. It's the ability to bounce back and learn from adversity. Psychologists have identified some of the factors that make someone resilient; among them are a positive attitude, optimism, the ability to regulate emotions, and the ability to see failure as a form of helpful feedback. Strong evidence from medicine, cognitive neuroscience, and psychology shows that the brain can be rewired and mindsets can change; in short, that we can intentionally adjust our behavior. We are all born with a certain level of resilience and increasing it is a learnable skill.

Why focus on resilience? The unknown quantity in safety is human behavior, and the overwhelming majority of incidents result from this behavior. External scientific research from the last two decades shows that employee engagement drives safety performance.

Shell developed a series of simple resilience training modules. (There are about 40 modules total; 15 are available on its website, https://hsse.shell.com/business/maritime-hsse-site.html, under "Care for People.") Each module takes about 30 minutes to complete; they don't require the presence of "experts" to provide training. They're simple but make people think. Fundamental keys to success of this program are to have someone who champions resilience, to assign senior accountability, and to support facilitators.

As a result of this effort, Shell has observed strong improvement in its rate of incidents.

Shell has also developed, with a consortium of other industry player, a "Maritime Wellbeing" app that's available in the App Store and Google Play Store. It isn't limited to resilience but is more broadly about human well-being in the maritime context.

Dr. Michael R. Benjamin (Research Scientist, MIT Computer and AI Lab, Department of Mechanical Engineering), Panelist:

Dr. Benjamin spoke about marine vehicle autonomy research at MIT, in particular the COLREGS (Coast Guard Collision Regulations) rules for navigation inland and in open water.

COLREGS describe what to do in certain situations and give protocols for collision avoidance. They were written for humans, who can use common sense, can improvise, and can generalize to handle unique, complex situations. They were written from the perspective of one vehicle at a time. If we want to bring COLREGS to autonomous vehicles, or to decision aids for manned vessels, we will have to be clever about how we encode those rules. We want an autonomous system to have the same high resiliency we get with humans following the COLREGS.

Dr. Benjamin and his colleagues have been working on marine autonomy projects since 2006, with approaches that utilize multi-objective optimization to resolve conflicts between various goals (e.g., to get from point A to point B, and to avoid collisions). The outcome of their system is a decision on heading and speed.

We want to have a COLREGS ruleset available for autonomous vehicles, so that as vehicles are approaching each other without any communication between them, they will have an understanding of what their roles are and know what the right thing is to do.

Dr. Benjamin's group released a version of the COLREGS rules in 2017. There are now some users who are using it on their vessels, and they have adapted and extended the code over the last several years. These users take the open-source code base and extend the capabilities to meet their own needs for their own customers. A lot is learned from their use of it. It reveals what capabilities in the open-source domain are of use to people and helps guide research. Looking forward, automating the simulation capability will be extremely important. The number of possible situations in which vehicles could encounter each other and need to do collision avoidance is virtually unlimited in the number of combinations. So simulation must be automated, and the software must be robust across a wide variety of cases.

Mr. John Jorgensen (Chief Scientist, ABS CyberSafety), Panelist:

Mr. Jorgensen spoke on the topic of reliability and resilience in the context of cybersecurity for mariners' onboard ships, offshore platforms, and in the marine world.

In automation systems shipboard, there are both potential and risks, and the risk is dual-sided. It's a risk of something happening, but also the risk of something not happening. The risks include things that we can account for, however; and how we account for them is in looking at the lifecycles of the requirements and of the systems, the ships, and the mariners that are onboard as part of that cycle. The automation systems connect to one another. We don't just install or integrate systems anymore; we also connect them, so they have interdependencies. We must think about what could happen if one of these automation systems doesn't perform as expected or fails.

Security is more than the protective functions put into place around a system. Human processes must be part of it. We need predictability and performance, which means knowledge of systems so that we understand exactly what they're going to do, when they're going to do it, and how they're going to perform. When you have correct knowledge, you can anticipate how they are going to perform and have expectations of what normal vs. abnormal.

We must consider what factors provide our operational risk posture insofar as, do we understand what's happening and how it's happening? Do we understand the security posture of a particular system of systems, and how capable the operators are, not just in operating systems but also in watching them to make certain that they function according to plan? Reliability and robustness go together intimately. Reliability is something you can understand and measure, in many cases, because it does have a definite linkage to probabilistic factors associated with the material condition of the systems. But the robustness gets to fault tolerance, and that leads directly to, do you understand the risk posture of your systems and whether they're going to function correctly or not?

We've devised a method for active risk management. We are pushing it every time we talk to people about cyber safety and cybersecurity. Effectively, an active risk management program is a cyber program that's put in place to accomplish what is necessary for the automation systems that are really, in effect, additional employees. You don't often think of an automation system as the equivalent of an employee or a mariner. But in reality, if it has a CPU associated with it and it's executing software, it's something that needs to be supervised just like a person. It's not as sophisticated as a person; it takes instructions well and will do exactly what it's told, but it doesn't improvise well. That's why you have to be very careful about supervision, so that you understand what measures must be put into place as minimum requirements so that you've got reliability and robustness built in.

Cybersecurity is important to those automated systems and software-intensive systems that we must operate and work with. It's not the only consideration. But

we must think about how to load the deck in our favor so that we have reliability and resilience built in, and cybersecurity is part of that.

Takeaway:

Some single takeaways from each panelist are as follows. (1) From Mr. Scalli, humans are the critical element. Shell tried to do the best they could to minimize all the close calls they have with human beings onboard. (2) From Prof. Benjamin, the autonomous software they put together at MIT is a tremendous piece of software that's being used and being customized to meet users' needs and is performing a very important function. (3) Mr. Jorgensen was really looking at active risk management: Assess how much risk you're willing to accept, and if you don't like a lot of risk, you can nail down a lot of it. It's just a matter of putting the effort and time and money into it.

KEYNOTE ADDRESS: "COAST GUARD RESILIENCE AND MISSION READINESS IN THE GREAT LAKES REGION," REAR ADMIRAL DONNA COTTRELL

Summary of Key Points

Admiral Cottrell provided a broad overview of some of the challenges and keys to success the Coast Guard has encountered in supporting resilience across the Great Lakes Marine Transportation System, and the Coast Guard's role in supporting waterway safety, security, and efficiency.

She first provided an outline of the Coast Guard's mission relative to maritime risk and described the importance of the Great Lakes. The Great Lakes Marine Transportation System is a network of interconnected lakes, rivers, ports, locks, and coastal waterways that permit cargo to move and connect us with the global supply chain. Every year, more than 160 million metric tons of cargo are moved on the lake system; more than 40 provincial and interstate highways are linked to 15 major ports and 50 smaller regional ports. This activity sustains a quarter of a

million US and Canadian jobs and generates $35 million in business revenues, as well as $14 billion in wages and salaries.

Point 1:

Any organization is made up of people, and people are where resilience must begin. A safe, diverse, healthy, and resilient workforce is critical. The foundation of operational, organizational, and systematic resilience is a culture that understands flexibility and embraces the concepts of our individual limits and when to seek help. This ensures that we are individually ready to respond to any emergency or contingency at any time and prepare for long-term response. It is accomplished through informed risk (i.e., using sound judgment and accepting no unnecessary risk), intestinal fortitude, and active engagement.

Point 2:

One of the hallmarks of the Coast Guard has always been the principle of flexibility. It implies that to succeed, we must be able to rapidly adjust to a wide variety of tasks and circumstances. Our units frequently face competing priorities as incidents unfold. For example, when the Coast Guard surges people and equipment in response to disaster, it may reduce or defer many activities in other operating areas. Surge operations are very demanding, but our ability to flow forces in an emergency provides an enormous benefit to the nation and serves as a testament to our flexibility. Our ability to be flexible accounts for a strategic, operational, and tactical success in our assigned responsibilities.

Point 3:

Successfully maintaining a resilient maritime transportation system in the complex Great Lakes is not achieved by a flexible Coast Guard alone. On the contrary, a resilient waterway system requires cooperative partnerships at all levels. Experience has demonstrated that establishing strong rapport with the maritime industry, waterways users, government partners, and other stakeholders prior to an incident or emergency facilitates a smoother and more expeditious recovery. The Coast Guard rarely conducts an operation alone. The interdependence, cooperation, and shared goals of the waterway stakeholders make waterways resilient, as a crucial advantage of well-established professional partnerships.

Takeaway:

The Great Lakes are a national treasure, and the Coast Guard has a key leadership role in supporting safe, secure, and efficient maritime commerce there. The successful resilience of the Great Lakes is a result of and dependent upon a culture

of (1) resilient individuals and our organizations and communities, a (2) flexible and agile multi-mission Coast Guard with clarity of purpose, and (3) strong established partnerships with maritime industry and government stakeholders united in pursuit of a common goal.

PANEL #3: RESILIENCE OF THE MARITIME SUPPLY CHAIN

Moderator/Chair: Dr. Joan Mileski (Department Head of Maritime Business Administration, Texas A&M University at Galveston)

Panelists: Prof. Leonard Waterworth, Dr. Paula deWitte, Dr. Cassia B. Galvao, Dr. Paul Koola, Dr. Amir Gharehgozli

Panel Abstract:

Maritime transport concerns the transportation of goods between two seaports by sea. The roles that maritime transportation has played in maritime logistics and the global supply chain have been well investigated in the past decade. An increasing amount of research has been done, offering suggestions and solutions for dealing with new challenges faced by practitioners and scholars who are striving to understand the new strategic roles of maritime transportation in global supply chains. While those studies have developed knowledge needed to understand why maritime transportation should be integrated into global supply chains, what stages maritime firms should go through in the journey of integration, and how to make a seamless global supply chain integration happen, maritime transportation is still isolated in global supply chains. Most shippers still regard maritime transportation as a turnkey solution to their tasks of moving cargo by sea, and most carriers and terminal operators still run their businesses in black boxes. Resilience is the science of preparing for, dealing with, and recuperating from shocks. This panel answers questions on barriers to the full integration of maritime transportation into the global supply chain—resulting in less resilience in the supply chain—and how to help practitioners integrate their maritime transportation services into their global supply chain. We will address information and communication systems, value-added services, multimodal systems and operations, and supply chain integration practices.

The panel also addresses disruptions and how ports are resilient to them. Ports are critical nodes of the supply chains serving important economic purposes and need to be resilient to disruptions. However, ports are complex systems, and their

operations are managed by multiple stakeholders that make them vulnerable to disruptions. In the United States, in the Gulf and on the East Coast, storm surge from hurricanes can cause major disruptions. Resilience relies on practices and processes. We will explore practices that lead to local resilience rather than global optimization. We must understand the impacts to port operations and to the extended supply chains and thereby improve their resilience.

In addition to the lack of integration of ports into the supply chain and disruptions caused by natural disasters, the panel addresses other threats supply chains face, such as the significant commercial challenges to facilitate trade, ensure profit maximization, perform cost recovery, and pursue environmental sustainability and securitization against increasing disruption risks throughout all stages from producer to consumer. Significant legal, environmental, commercial, political, social, and physical risks all threaten the quality of maritime trade and the supply chains. Risk management methods have prioritized disruptions, from strikes, inventory disruptions, port congestion, financial crises, and terrorism to accidents and climate change. Understanding risk management methods can help provide for building resilience.

Prof. Leonard Waterworth (Executive Professor, Texas A&M at Galveston), Panelist:

Prof. Waterworth talked about his observations of effort to improve resiliency against "black swan" weather events in the Houston area.

The port at Houston, Texas in Galveston Bay is the number-one port for foreign tonnage. Overall, it generates about 3.2 million jobs and over $800 billion worth of economic activity; it's an economic engine that is driven by about 10,000 deep water ships and over 200,000 barges.

In the context of risk mitigation to the maritime business, looking at "black swan" events, there are risks at that port: risks from floods, hurricane surge, rainfall, and so on. In 1900, a storm killed over 6,000 people; it essentially moved Texas's premier city and port 52 miles inland. With Hurricane Harvey, over 50 inches of rain fell in about 72 hours. So, we have events; the question is, what do we do?

We know from historical averages that we're going to see a category 3, 4, or 5 hurricane every 12 to 13 years. In September 2008, six hours before Hurricane Ike hit, it was forecasted to go right up the Houston Galveston Ship Channel; there were predictions that there would be a 27-foot surge in downtown Houston. But it veered off at the last minute and we had an event that cost the nation "only" about $30 billion.

That was when we started thinking about, how do you mitigate? How do you build resiliency into this region that has an economic engine? The concept of the Ike Dike was born. The response to the 1900 storm was a seawall. Ike Dike was going to be an extension of the seawall but with new technologies. The berm itself was going to be sand, but the premier feature was going to be gates across Bolivar roads. The gates would hold back storm surge, not allowing the water in the Bay to increase, because that was where danger came from when the water in the bay went from 12 feet to 20 feet and got pushed around by the wind.

So how far has the idea gotten, as of today? We've had to work through local governments, through the states, through the federal process, with the Corps of Engineers. The Corps of Engineers essentially started a study of the entire Texas coastline. They will come out with a port that essentially adopts the Ike Dike, the coastal spine, and gates across Bolivar roads as the federally preferred plan. A final report should go to the chief of engineers and hopefully off to Congress by the middle of 2021.

Dr. Paula S. deWitte (Associate Professor of Practice, Texas A&M University), Panelist:

Dr. deWitte spoke on the topic of cybersecurity resiliency. If a port is hit by a cyberattack, the consequences can be as bad as those from a weather-related "black swan" event. A black swan event is one that has a low probability of occurring but may have disastrous consequences. Consider the Houston port that Prof. Waterworth discussed. What happens when it's crippled by a cyberattack, and how could such an attack happen? You could attack the automated ships, the vessels; you could attack the port operations itself; you could attack the supply chain.

"Cyber resiliency" is a concept that's used quite a bit in other areas and is just now gaining traction in maritime. What it basically means is, can we keep the systems operational while under a cyberattack?

A good lesson is occurring now. The information technology (IT) systems of the CMA CGM company, a French company, was attacked last week by ransomware; they are not yet up to full capacity. The ransomware locked up their systems such that they can't schedule; they can't track containers; they can't figure out what's going on. The maritime systems and environment are highly automated and are becoming more automated, but we haven't been adequately addressing the concept of cyber resiliency. Can we maintain the operation of cyber-physical systems so that they continue to operate while the systems are under cyberattack?

The maritime environment is a highly valued critical infrastructure. Attacks are being carried out by both criminal and nation-state attackers. Criminals are after

the money; nation-state attackers are after our national security, our economy, and the health, safety, and well-being of the nation. And we're seeing increasing attacks on the maritime transportation system, with the same possible consequences as a hurricane: an attack can cripple our ports, cripple our economy, and leave us dead in our tracks.

All four major international shipping companies have been the victims of ransomware attacks in the last few years. Maersk got close to being completely wiped out in 2017 and was spared only because a power failure in Ghana prevented a Maersk-owned system from downloading the NotPetya malware. And it wasn't even a targeted attack; it was an accident! NotPetya was ransomware that the Russians were putting on Ukrainian systems, and it got out into the wild and somehow got to Maersk. It was a disaster; they got within five days of completely losing operations. So we are becoming a target of big, well-funded nation-state attacks and criminal attacks, and defending against them is important to keeping our health, our safety, and the well-being of our national and international economies.

Dr. Cassia B. Galvao (Assistant Professor, Texas A&M at Galveston), Panelist:

Dr. Galvao spoke on the topic of port governance and resilience at port governance. She structured her presentation around 3 questions: (1) What are the typical port governance dynamics? (2) How is resilience measured? And (3) what is the relationship between governance and resilience in the port business?

The governance dynamics in ports borrows a lot from traditional business governance models, but with some particulars associated with ports.

Governance is about the way rules are formed, the way they are enforced, and the way they influence how decisions are made and people are held accountable. It boils down to authority, accountability, and decision-making. When we apply that generic governance framework to ports, we have to deal with a degree of interaction, indeed conflict, between public and private actors or participants because of how ports are established: the nature of the physical infrastructure, the way operations are done and labor is hired, and of course, the cargo owners or the beneficial cargo owners (BCOs). There's going to be complexity because of that.

Over time there has been an increasing need to change port governance, i.e., to adapt, modify, or introduce new regulations. So new regulations are introduced. The whole idea of a port is to move cargo as quickly, cheaply, and efficiently as possible, and the addition of new regulations in a highly regulated industry sometimes impacts efficiency levels. Every time a new regulation, a new set of

rules, a new law has been passed, a new regulatory body was created, etc., the port governance changed, and operations were impacted again. It has become, to a certain extent, a permanent job in the port's governance structure to deal with these new regulations. It's become part of strategic planning, asking what will be the next thing that changes.

You cannot really manage what you cannot measure. If operations and performance depend on how well you operate, the financial side is a way to measure performance. But we must take into consideration everything that might happen, mapping all the risks and vulnerabilities before we take precautions. The solution is to measure by time. How fast can you go back to your normal operations after some disruption happens?

If resilience is measured by time and performance, a port's performance is heavily impacted by governance. So, the idea of discussing a good governance and incorporating a resilience plan is acute for all ports.

The final takeaway is that governance sometimes brings about a lot of discussions and how flexible an organization can be with so many rules and so much process in place. And if resilience is measured in time, at some point, those two things are going to be in conflict. So flexibility is the name of the game that ports must play, now more than ever.

Dr. Paul Mario Koola (Professor of Practice, Texas A&M University), Panelist:

Dr. Koola offered "an engineering perspective on maritime supply chain resilience."

Resilience is the capacity to recover quickly from difficulties. A system is resilient if it can adjust its functioning prior to, during, or following events (changes, disturbances, and opportunities), and thereby sustain required operations under both expected and unexpected conditions.

If you look at the maritime supply chain at its highest level, it's a sociotechnical system. Human operators, technology, and organizations are all involved, so it's a complex system. And in today's global economy, organizations work together in networks instead of competing as isolated entities. As a result, these systems are exposed both to natural risks, like hurricanes, and to manmade risks, like cyber threats. So, resilience is what empowers proactive response to changing market demand and disruption. Currently, the focus is more on operations and has not incorporated too much the voice of the customer.

David Woods of Ohio State University says there are four senses of resilience; in simpler systems, they include (1) ability to rebound from shock, and (2) "robustness," i.e., the ability to adapt to well-modeled disruptions. In complex, adaptive systems, they also include (3) graceful extensibility (the ability to stretch beyond the boundaries for which the system was designed), and (4) sustained adaptability to cycles of change. Therefore, to achieve resilience, the goal is to build and sustain systems' adaptive capacity.

Looking at the bigger picture, what we really need to meet is the customer requirements of our service: hassle-free, real-time shipment, and so on. One potential solution for a better architecture could be the *QFD* (the *quality function deployment methodology*, as described by Jasmine Siu Lee Lam and Xiwen Bai[2]), with which you take the customer requirements and then map them to the maritime risk through a relationship matrix. It's another way of looking at building a better architecture to understand the entire system.

Maritime supply chains (MSC) are complex adaptive systems. There is no way to design for unknown possibilities; machines & AI cannot predict the unknown unknowns. We must train people to adapt to new situations. The solution will be resilient systems consisting of machines that automate routine tasks plus humans who adapt at the boundaries outside design specs. We must have an ongoing process of continuous improvement in which we constantly cooperate, learn, and adapt.

Dr. Amir Gharehgozli (Assistant Professor, California State University, Northridge), Panelist:

Dr. Gharehgozli talked about blockchain in maritime supply chains, including its benefits, challenges, and limitations in connection to maritime risk.

Maritime trade is 80% of global trade by volume and 70% of world trade by value, so a huge amount of trade happens on the oceans. It's a global supply chain that's dealing with a lot of challenges. For example, we cannot efficiently and effectively integrate national and international systems of China, the US, and Europe. We lack transparency and flexibility.

One solution that can improve the supply chain is blockchain. Blockchain is a new distributed information technology with which all data (sales, shipping, design) collected through different parts of the supply chain must be validated before becoming a permanent record. The decentralization attribute of blockchain

[2] Jasmine Siu Lee Man and Xiwen Bai, "A quality function deployment approach to improve maritime supply chain resilience," *Transportation Research Part E: Logistics and Transportation Review*, vol. 92, August 2016, pp. 16–27. https://doi.org/10.1016/j.tre.2016.01.012

facilitates the secure distribution of data across a network, as no single node alone can control the whole transaction. It is a new paradigm that can enhance the traceability of production and logistics activities. It reduces the role of intermediaries whose servers are vulnerable to crashes, frauds, and hacks. It increases efficiency and transparency and provides a record of transactions that cannot be tampered with or altered.

In essence, we are moving from a traditional system with a central authority that processes transactions to a distributed blockchain system in which multiple nodes process transactions at the same time. The new system is perfect for a supply chain in that many parties can share information with each other; currently, information is shared from one party to another, and many involved parties don't have information that would allow them to do more efficient planning. Blockchain will help with that.

What are some of the advantages of blockchain? Reduction in paperwork and the associated costs; reduction in transaction time; enhanced transaction security; optimization of port operations; and improved sustainability. There are also some disadvantages and impediments. Blockchain is expensive to implement; you need a lot of IT infrastructure and a lot of electricity, and many companies are not ready for that. Second, there are inadequate laws and regulations, as blockchain is such a new technology (dating to just after 2008). Third is resistance to change. There are huge companies in the maritime supply chain that have been doing things a certain way for 200 years. On top of that is technology change: blockchain is still developing and faces technical challenges and lack of standardization.

We must encourage maritime companies to implement blockchain. We need for them to see successful blockchain applications in other fields, and we must provide them with experts in blockchain who can help them implement it.

Takeaway:

Resilience must be looked at through a variety of lenses—an interdisciplinary approach in which we think in terms of a "wicked problem," wherein things can be fixed in one area, but then that fix affects other areas. We can consider the digital aspect of the supply chain, and how blockchain may help create resilience; we can consider how port governance can help us be more resilient. We can work to better engage stakeholders, and get help from local, state, and national governments to make our infrastructure more resilient to lead to a better supply chain.

PANEL #4: MARITIME RESILIENCE AND CYBERSECURITY

Moderator/Chair: Dr. Kim Young-McLear (Fellow, Department of Homeland Security, Cybersecurity & Infrastructure Security Agency)

Panelists: Mr. Zac Staples, Prof. Kevin Jones, Dr. Jagruti Sahoo

Panel Abstract:

Across the world, 2020 has been challenged with COVID-19, and we have observed that no sector or industry is immune to disruptions. Whether disruptions are artificial or natural, or a combination, we have seen that transportation sectors, including maritime, are particularly susceptible. Given the global dependency of the maritime transportation system (MTS) and the new combined risks of cybersecurity and COVID-19, this moderated panel features a range of emerging issues facing the MTS.

For both national security and economic prosperity, a resilient maritime transportation system is vital. Maritime commerce accounts for more than $4.5 trillion annually in economic activity. It is the lifeline for the global supply chain, yet it is a vast network of operations that is virtually hidden from the general population. According to the US Coast Guard, approximately 90 % of American imports and exports occur via commercial vessels. In fact, it is estimated that within the next five years, the global demand for maritime commerce in critical sectors will double. Because of the unique threats and challenges, new MTS research, regulations, and legislation continue to expand to address the ever-increasing complexities in this domain.

Cybersecurity threats facing the maritime transportation system will have a cascading impact on the domestic and global supply chain. Although it is not well known to the general public, the Coast Guard plays a vital role in mitigating cybersecurity threats in the MTS. The US Coast Guard is the lead federal agency designated to protect the MTS. As the primary regulator of the maritime industry, the Coast Guard is focused on managing risks to critical infrastructure. The Coast Guard accomplishes this through promoting unity of effort among stakeholders in

the MTS. The Coast Guard also coordinates efforts with the newly established Cybersecurity and Infrastructure and Security Agency (CISA) at the Department of Homeland Security.

Emerging technologies and an expanding cyber threat landscape pose unique challenges to the MTS and port systems are fast becoming more digitized. This digitalization significantly increases operational risk because it can be exploited intentionally, or be disrupted unintentionally, resulting in serious harm, injury, death, or vital disruption to trade. The COVID-19 pandemic allows us to see even more clearly the importance of a resilient supply chain in times of emergency. From a commercial and regulatory perspective, it is no longer feasible to assume or rely on IT cyber solutions as adequate risk mitigation for cyber incidents to operational systems. The US Coast Guard, however, continues to modernize to manage risk in the MTS, optimize navigation systems, and enhance regulatory frameworks.

To solve the complex cybersecurity challenges facing the MTS, a transformation of thinking, collaboration, workforce capacity, and traditional partnerships is needed. Even though the US Coast Guard has published new guidelines for addressing risks in the MTS, we must continue to develop solutions that collectively provide a robust range of risk management against different types of cyber incidents. The innovative solutions from the Coast Guard and maritime partners are being developed, evaluated, and tested each day through research, testbeds, and policy. Examples of such solutions and potential solutions are highlighted by the panelists.

Prof. Kevin Jones (Executive Dean, Faculty of Science and Engineering, University of Plymouth), Panelist:

Prof. Jones shared his perspective on maritime cybersecurity and his research in this area.

Just a few years ago, cybersecurity in the maritime domain was barely discussed. We then began to recognize the interconnectedness of systems and how effects in one part of the space would have serious consequences in other parts of the space. The Maersk incident was a watershed event because that made it clear that there were real cyber consequences for companies in the maritime sector.

Since then, we've seen many more sector-targeted threats, both shore-based and ship-based, with a preponderance being shore-based. We've seen a 900% increase reported in the industry in the last three years—an alarming trend. There's now a clear business model for attacking the maritime sector, and that means that trend will continue. Once there is an obvious model for making money out of attacks on

a particular sector, you'll see more and more people being involved in such incidents.

The maritime sector is, really, not worse off than most other sectors, and we're sharing common problems and common solutions. However, a lot of the operational technology in the sector was designed at a time when security, if it was considered at all, was considered an IT issue, and is certainly not robust in the face of a focused cyber attack aimed at known or recently discovered vulnerabilities within those sorts of devices.

Under COVID, we're seeing more and more of the world's business going fully online. It has shown the dependency we have not just on information systems, but on physical transport, particularly ocean-based transport. It's clear that there isn't a lot of resilience throughout the entire supply chain.

Good practices and policies, often inherited from the IT community, can mitigate the kind of low-level threats we're seeing today. But there are far fewer easy or off-the-shelf solutions for maritime-specific technologies, and the emerging trend towards focused attacks is cause for serious concern. We're going to need sector-specific collaborative research that addresses technologies and practices that are specific to the industry.

Prof. Jones has been building a "Cyber-SHIP Lab," which allows his team to recreate specific configurations of bridge-related equipment and networks, and to perform realistic threat analysis with sophisticated tools, including AI-based tools in a hardware-accurate environment. He believes we need more initiatives that are specific for the sector, so we can move into a regime where cybersecurity is as much a part of the infrastructure as resilience to equipment failure is today.

Dr. Jagruti Sahoo (Assistant Professor, South Carolina State University), Panelist:

Dr. Sahoo shared her research on the Internet of Things and cybersecurity and discussed some of the cyber threats in maritime IoT.

IoT has brought a major transformation in the way we interact with the physical world, and we also now have data analytics technology that can help us make smarter and better decisions based on the data we can obtain. As a result, we seen tremendous growth in the adoption of IoT technology in various domains, including the maritime domain. For example, various IoT sensors, such as pressure sensors, gas sensors, and vibration sensors, are used to monitor different parameters of ships; e.g., in container tracking applications, humidity and temperature sensors sense the internal condition of a container, and GPS sensors provide the location of the container.

IoT devices are vulnerable to cyber-attack for several reasons. They have static footprints, as they don't receive updates very often. They have resource limitations, so attackers can launch energy depletion attacks, just running down the devices' batteries. Weak security protocols are a factor; the devices don't have enough resources to support complex security protocols. Wireless transmission is broadcast in nature, so anyone can bring a sniffer and can try to capture the data. Finally, there is a high volume of data, which can include sensitive and personal information. Those factors make IoT devices attractive targets for attackers.

So how can we address those cyber threats? One solution could be moving target defense (MTD). MTD works by changing the attack surface dynamically across multiple system configurations. The goal is to increase uncertainty and complexity to discourage attackers.

But there is a key challenge: how do we determine an optimal MTD strategy? (Which parameters do we randomize? How frequently do we randomize them? Which MTD technique should we choose?) We can solve this decision problem by using reinforcement learning (RL). In RL, an agent interacts with the environment, executes a certain action, and gets a certain reward; so the agent just tries to execute actions to optimize the reward.

In Dr. Sahoo's work, deep reinforcement learning has been developed that requires less memory and training time than traditional RL, making it possible to use MTD for any IoT domain. She provided some example scenarios in which MTD could be used to increase the resiliency of a maritime system, complementing existing traditional security measures.

Mr. Zac Staples (Founder & CEO, Fathom5), Panelist:

Mr. Staples works at Fathom5, which is the onboard cybersecurity provider for one of the largest US flag carriers and works extensively with the US Navy. They also work with the public on defining what is possible in maritime cybersecurity.

A lot of software is at sea now on operational technology systems. There's an IT/OT bridge and fuel management, route optimization, crew scheduling, fleet scheduling, and cargo scheduling—many of which are being run onboard, many of which are being run in the port—and almost all of which are being monitored or run directly at the shipping headquarters. All those things are running on traditional IT servers. So, there's a real convergence of IT and OT.

The way you make a ship (which is built by multiple vendors) work as a system of systems is that you don't put any authentication between anything. That allows a third-party software provider to come in and deploy a technology onto your ship. It also creates IT to OT crossover potential. It creates vulnerabilities, and it creates a

mandate for people who are serious about securing the maritime transportation sector to be analytic, detail-oriented, and driven about what they must achieve and to be security-minded from the start when they think about maritime digitization.

We must start doing the deep science, and we must start building foundations for lab and float tests. Fathom5 has developed a maritime cyber testbed that gives people an opportunity to gamify ideas at low cost to study in a lab environment whether their operational technologies and their IT integrations might have vulnerabilities and allow them to test-drive security.

There are two threads to resilience that probably need to be part of the discussion, the technology, and the implementation strategies. The first is that maritime resilience in cybersecurity is important for the fleet, for the ports, and for the headquarters; and there's a technology resilience to that. Second is the component of sector resilience; people want to create a more resilient set of shipping and infrastructure. Software optimization and digitalization are going to play a huge part of that.

Shipping companies are asking questions about how to reduce costs and compete in a more dynamic market. The solutions they're going to implement are going to have a strong software component. So, the complexity and the amount of software tied to the operation of this sector are going to explode to make the market sector more resilient. We must therefore move very quickly as a community of practice in the cyber component, to ensure that the right decisions are made for the implementation of those cybersecurity tools.

More and faster maritime digitalization is coming, and it's time for the community to get ready for that.

Takeaway:

Maritime cyber has unique problems that require unique solutions. Creative thinkers across many fields of expertise can make significant contributions here. The best academic problems are the ones that are hard and require broad thinking, so you can't solve them easily and people actually care if you do. It's a great opportunity. There are interesting technical problems, and interesting practical problems. We can take it as a challenge.

KEYNOTE ADDRESS: "THE EVOLUTION OF RISK MANAGEMENT IN MARITIME: AN AIR & SPACE ANALOGY," REAR ADMIRAL MICHAEL FOSSUM

Summary of Key Points

Admiral Mike Fossum spoke about the evolution of risk management in the maritime setting, sharing anecdotes and drawing on analogies with his experience in the Air Force and as an astronaut on the Soyuz spacecraft and the Space Shuttle.

Point 1:

There are a lot of similarities between the maritime and air & space settings. A major one is that the endeavors are often intrinsically dangerous. Even so, you learn to do what you need to do; you work together as a crew to pay attention to what's going on, to know your systems, to make certain that you're following parameters precisely and doing so as safely as you possibly can.

What you're doing is managing risks. Anybody who isn't a little bit concerned doesn't really understand what's going on. We train air crews never to be

complacent, but despite all the progress that's been made, human errors can still bite you.

Point 2:

It starts with the professionalism: you have to know your craft; you have to know all of its systems. In the Air Force, there are required annual proficiency examinations and check rides with instructor pilots to make sure that everyone is ready to handle the abnormal, is ready for the bad day, and has the depth of system knowledge that they need to handle the unexpected. You've got to know your systems absolutely; you've got to know it cold, you've got to know all the interactions, and you have to train to recognize those glitches that are out there. You must learn how to recognize things and how to work together.

Point 3:

The term that we used at NASA was *error trapping*. The idea was that if every critical decision, every critical move, gets a second set of eyes on it, there's a chance to prevent something from becoming an error. If the error is trapped before the switch is thrown or the incorrect action is taken, then you haven't really committed an error; nothing bad has happened. It's helping everybody understand that we are all human, we all make mistakes. At NASA, it was called *crew resource management*. In the maritime world they talk of *bridge resource management*; it's the same concepts.

Point 4:

How are the maritime and flight settings similar? In a big way, it's about professionalism. It's about error trapping. It's about training and always maintaining that professionalism in your crew so that you trust each other, and you know everybody on the crew can speak up with a concern. It's really set by the captain or the commander. NASA has had commanders that didn't want anybody to interrupt them or tell them what they thought, and that's dangerous. The captain's got to instill that spirit of teamwork and trust, which empowers the team to speak up. Those things are so important.

It's the same in the maritime and flight settings. The essence of being a good crew member is the same. It doesn't matter if you're in the air, if you're in space, or if you're on the crew of a ship at sea. It's all about professionalism: know your stuff, work hard. Everybody wants a crew member who works hard and gets along well with others. That's the kind of people we all want. And really, when we're talking about those basics of being a good crew member and how we enhance the safety of maritime operations, it's error trapping, its professionalism, it's setting that

standard from the top down on every vessel and every company on what the expectations are.

Point 5:

It's important to learn the lessons from the days when everything doesn't go as well as you wish it would. You've got to learn from the mistakes; you've got to have the hard conversations and make sure that you get as much benefit out of every incident as possible to help reduce the probability of it happening again. We as leaders must look for ways to bring in that body of knowledge and help our cadets and mariners be ready for the bad days, because they're going to have them. If you're in this business as a crew member, any length of time at all, you're going to have a bad day, whether it's in air or space or at sea. And that's our job: to be ready to trap errors and have the team respond as necessary.

Takeaway:

The key to managing the risk is teamwork and developing a culture with the crystal-clear expectation that every member of the team must be alerted to risks and free to speak up to mitigate them.

PANEL #5: INLAND WATERWAYS AND THE GREAT LAKES RESILIENCY

Moderator/Chair: Dr. Craig Philip (Research Professor and VECTOR Director, Vanderbilt University)

Panelists: Dr. Michael Meyer, Ms. Katherine Chambers, Dr. Mark Burton

Panel Abstract:

Inland networks differ in many ways from other maritime systems, but, particularly when viewed through a maritime lens, two key characteristics are crucial: inland systems (1) are often characterized by a linear topography and (2) exhibit non-redundant functionality. Additionally, in the US, ownership and management are both centralized and decentralized. The inland system is primarily owner-centric in ownership and management of the infrastructure (locks, dams, dikes, and levees) by large governmental and quasi-governmental agencies. Meanwhile, the ownership and operation of the ports and terminals are often decentralized and privately managed, with some ports simply being a collection of independent terminals and other facilities.

This panel includes three prominent researchers who have been deeply involved in recent projects that explored various aspects of inland maritime system resilience.

Dr. Michael Meyer (WSP Consultant and Study PI), Panelist

Dr. Meyer spoke about a project that was completed last year by the National Cooperative Freight Research Program of the Transportation Research Board that looked specifically at disruptions to the supply chain, and was intended to do three things: to better understand the characteristics of disruptions, to consider analysis tools for predicting the results of disruptions in terms of flows, and to develop a guidebook that could be used by both public agencies and private firms to enhance

organizational resilience capability[3].

The project looked at what it means to be a resilience-oriented agency, i.e., to be an organization with the ability to prepare for, plan for, manage, and then recover from expected disruptions.

In terms of the characteristics of the disruptions, the team looked at all types of commodities, all types of modes of transportation, and different characteristics of disruptions. They identified three major types of disruptions: (1) those that are abrupt and unexpected, that weren't planned for; (2) ones that occur with a little bit of advance notice, such as a hurricane; and (3) predictable ones, like you're going to be redoing a major highway and it's planned so you can put in place strategies to minimize disruption. Also, regarding the disruptions, there are different levels of loss: (1) *severe impact* with national and international economic costs; (2) *high impact* that's more regional and national in nature; and (3) *low impact* losses that are specific to a locality or site. The geographic scope is also important, primarily because it dictates who would be involved, especially from the public sector.

The team looked at the different combinations of disruptions with low, high, or severe impact, and the extent to which there could be advance planning about issues related to abrupt disruptions. They tried to understand the different dynamics associated with different types of disruptions for different types of modes, and to identify various things can contribute to system resiliency, including aspects of physical infrastructure, logistics, finances, communications, regulations/oversight, and institutional factors. Those elements all became important parts of the effort to develop strategies to enhance system resilience overall.

One of the project's major contributions was on how organizational capability relates to resilience in terms of how you prepare your organization to handle resilience issues better, both in responding to short-term disruption and in enhancing the capability of your organization over the long term, staff wise, training wise, and tool wise.

They developed a seven-step process, which they argued was a framework for thinking about how to incorporate resilience into an organization. Each step includes a kind of a self-assessment approach that an agency could use to clarify where it is currently and what it could do to implement strategies to enhance its resilience capability. Notably, a lot of organizations neglect the longer-term aspect.

[3] The resulting publication, *NCFRP Research Report 39: Freight Transportation Resilience in Response to Supply Chain Disruptions*, can be obtained from http://www.trb.org/Publications/Blurbs/179096.aspx.

More could be done for the broader, long-term perspective.

With regard to public agencies and their role, care must be taken because of rules and regulations designed to prevent a public agency from spending tax dollars in a way that favors one company over another. Also, such agencies naturally focus on whatever sector they're responsible for, but to get a really resilient system, coordination and collaboration are needed among many entities.

Ms. Katherine Chambers (Research Scientist, ERDC, US Army Corps of Engineers), Panelist

Ms. Chambers spoke about another effort to study what resilience means for the Marine Transportation System.

In her view, resilience should be envisioned as a four-stage cycle in which you (1) prepare; (2) withstand damage and absorb impacts; and (3) recover from disruptions; and then, eventually, (4) learn and adapt to be better prepared for the next disruption. To make a system more resilient, all four stages must be considered.

The Marine Transportation System is a complicated system that includes inland waterways. There are geographic elements of the system, and all the other systems that govern how that geographical system works. There are physical systems that are responsible for moving cargo and people. There are transactional systems that manage procurement, tracking, and distribution of cargo, and regulatory and oversight systems. So, there is much to consider when we talk about the resilience of this system.

Then there are disturbances and stressors, which include a range of routine concerns, with climate change and episodic events being additional factors that affect those concerns.

Figuring out what resilience means can be subjective and applied variably. There are planning frameworks, interdependency assessments, and hazard impacts and modeling. There are tools and capabilities that are very specific. There are self-assessments. There are toolkits that are more applicable to broad resilience questions. It can be very confusing. And there's a disparity between the published material on resilience, and things that are usable for decision-making for specific problems that someone is trying to define within a specific port area.

Ms. Chambers has been part of an effort to develop a port and marine transportation system assessment guide to provide a replicable framework for conducting resilience assessments. It's not creating new resources but pulling together the valuable resources that already exist and pointing people to them (and

providing additional resources within appendices). The new thing is a way to organize the existing methods according to key resilience assessment objectives that can be considered in order to do accurate and holistic resilience assessments.

It's a tiered framework in which tier 1, the lowest tier, is where you try to understand your system and prioritize how its functions work; tier 2 is where you figure out how the system is structured and how it might respond to a hazard or disruption; and tier 3 is where you compare alternatives and create a plan to make your system better. The approach is organized according to objectives. The first objective is to characterize the system; the second is to identify critical infrastructure and dependencies; and the third is to understand the impacts of disruptive events.

(For more information on the ideas outlined in this talk, see the PAINC EnviCom Task Group no. 193 report, *Resilience of the Maritime and Inland Waterborne Transport System* (2020), available at https://www.pianc.org/publications/envicom/tg193. It not only outlines components and stressors, but also provides case studies and examples.)

Dr. Mark Burton (Interim Director, Appalachian Transportation Institute, Marshall University), Panelist

Dr. Burton provided a brief description of the 383-mile Illinois River system, its economic importance, and the way that it interacts and competes with the railroad industry, and then looked at the issue of resilience and how navigation is of specific importance to resilience in the Illinois basin.

The US and Canada are probably the only two places in the world where the private sector controls the rail side, and the inland navigation is provided by the public sector. The Illinois system is a good example of the way that private sector railroads and public sector navigation interact. Where navigation is available, it has an inherent and indisputable cost advantage, so that shipments that occur from origins or destinations that are very near the waterway are going to move on the waterway. However, as you move away from the waterway, users incur a cost to connect to the river. So, at some point, there's a balance between the rail cost at a specific origin or destination, and the combined truck and barge cost, and that generally determines which modal combination is used. Traditionally, that distance has been between 50 and 100 miles, so that shipments a hundred miles from the waterway will go by rail. There have been, however, anecdotal suggestions that that distance is increasing.

There's an issue of rail capacity, which is a hot-button issue among shippers in the Illinois basin. That capacity is broken into three pieces: (1) the terminal capacity at

the origin in Illinois, (2) the line haul rail capacity that connects that origin to the Gulf destination, and (3) the permanent capacity at the Gulf. The piece that presents a real issue is the first, the terminal capacity in the Illinois basin. Because railroads find it difficult to compete with barges, they make fewer investments in terminal facilities in the basin. Trucks line up for miles trying to get into a rail facility.

Turning to resilience: Railroads continue to invest heavily in their network, but part of the way they make that investment effective is to limit the extent of that network so that the network is not nearly as robust as it has been in the past. As you reduce the network's extent, you limit redundancy, and that affects flexibility and reliance in the face of any sort of unplanned rail network disruption. So, the network is much smaller than it has been in the past. If you take that into account, maintaining or enhancing large network capacity may be a very important policy prescription.

Finally, looking to the future. Illinois infrastructure on the river is being upgraded, and the upgrades are significant in providing reliability in the future. Automation is likely to affect all modes: truck, rail, and navigation. As automation occurs, and depending on how it occurs, that will change the costs of each mode of transportation, and therefore the relative costs, which is likely to shift traffic around from one place or another. Next, there are opportunities for cost sharing, and Illinois and the users of the Illinois River have led the way in discussing the regional contribution to investments in the waterway system, although the outcome remains to be seen. And the final issue, looking at the future, is how international markets may change. A great deal of the production within the Illinois basin is export grain. To the extent that the demands for that grain change geographically, it'll change the relative importance of each mode and the modal shares. The demands for grain from China have been volatile and are likely to remain volatile, so that's going to move around the export locations, and therefore the modal use.

Takeaway:

This panel looked at resilience from three widely different perspectives, and indeed this sector needs input from a wide range of perspectives if we're going to deal successfully with the nettlesome issue of resilience.

There is a complicated interplay between the public and private stakeholders that impacts maritime system resilience. We need to think about different modes that allow various stakeholders to channel efforts and work to achieve resilience-enhancing options.

In addition, the maritime freight domain is multimodal, and the various actors don't always work well together, given the competitive dynamics often involved. But resilience enhancement can happen only if we can take a true multimodal perspective.

PANEL #6: LESSONS FROM RECENT DISASTERS

Moderator/Chair: Dr. Henry Willis (Director, Homeland Security Operational Analysis Center, RAND Corp.)

Panelists: Mr. Aaron Davenport, Ms. Jennifer Carpenter, Capt. Jason Smith

Panel Abstract:

The maritime sector is challenged to remain resilient against numerous disasters, attacks, and accidents. The last several years demonstrate the variety of events that could challenge the sector. Whether it is hurricanes (e.g., Harvey, Irma, and Maria), cyber-attacks (e.g., the NotPetya disruption to Maersk), oil spills (e.g., Deepwater Horizon), or even the disruptions from the on-going COVID-19 pandemic, the maritime sector must respond, adapt, and recover to maintain resilience when confronted with extreme events. As challenging as the events of the last few years have been, geologic history tells us that worse events could happen. National-level exercises have tested response and recovery to extreme events that we have been fortunate enough not to experience in modern times, such as the New Madrid earthquake or a solar storm affecting a wide area of the US. They are just a few among countless disaster scenarios that the maritime sector must be resilient to. Fortunately, we can learn from experience, and if there is a silver lining, the last few years provide lessons on how disasters challenge the maritime sector, what steps the sector can take in response, and what questions the sector should answer as it seeks to be more resilient. This panel focuses on these issues by drawing on lessons from research, the private sector, and the USCG.

Mr. Aaron Davenport (Senior Policy Researcher, RAND Corp.), Panelist

Mr. Davenport spoke about the efforts of the Homeland Security Operational Analysis Center (HSOAC) to assist FEMA and the government of Puerto Rico with recovery after the devastation of Hurricanes Irma and Maria in September of 2017. He highlighted some of the work and how it relates to resilience.

FEMA asked HSOAC to do a damage and needs assessment post-hurricane and provide supporting documentation for the report, which was being drafted by HSOAC in concert with the government of Puerto Rico and FEMA. Briefly,

HSOAC's approach can be summed up in four major lines of effort: collaboration with the government of Puerto Rico, identification of possible courses of action, identification of collections of courses of action that could meet strategic objectives and conducting of decision support exercises with the Puerto Rican government.

A damage and needs assessment were done specifically for the maritime sector. It included damage reports and interviews with port and government officials. It looked not just at the physical condition of the port, but at understanding the nature of activity in the transportation system before, during, and after the hurricanes.

It emerged that many of the ports were in poor condition before the hurricanes struck. There appeared to have been a lack of operational maintenance and normal upgrades. Although there was flooding, the structural issues with the piers seemed to be preexisting. The port operations were largely restored within a short period of time, primarily because Puerto Rico is focused and uses the Port of San Juan more than any other ports. So perhaps part of their ability to bounce back was that there was only one port that was taking the bulk of the logistics and supplies.

To break down what the team thought Puerto Rico needed to do to recover, they thought a sense of the magnitude of the damage was needed, and a sense of what would be needed to build resilience into their port. A baseline of maritime activity was established via collaboration with the US Army Corps of Engineers, which has done some studies. One of the tools they've used is the Automatic Identification System (AIS), which provides the location of a vessel every few seconds. Interestingly, the AIS data showed that Puerto Rico was already on a decline. So, the AIS data were very helpful in revealing what was going on in Puerto Rico before, during, and after the hurricanes.

Six courses of action were identified for the maritime sector: (1) develop redundant seaport capacity (to relieve the heavy reliance on San Juan), (2) support infrastructure asset management, (3) repair damage to ports and ferry terminals, (4) reassess the maritime transportation system recovery plan, (5) do long-term planning to develop the Deepwater port of Ponce as a regional transshipment hub and increase its capacity, and (6) consolidate port ownership (because the large number of owners and arrangements made things more complicated).

The final estimate was that it would take approximately $1 billion to restore the Puerto Rico ports to full functionality, another half a billion dollars to upgrade them, and $400 million to provide some new capacity in the port. The marine transportation system for an island economy is so important, and Puerto Rico is in a good position because of its location in the Caribbean and the deep port that it has; it could become a transshipment hub over time if the investment is made.

The publicly available report can be obtained online[4]. It provides all the supporting documentation for the transportation sector.

Ms. Jennifer Carpenter (President and CEO, American Waterways Operations), Panelist

Ms. Carpenter shared her perspective on how we can preserve and strengthen the resilience of the marine transportation system, with reference to the ongoing experience with COVID.

The pandemic provides an opportunity to assess what's working well, and what must be improved to strengthen our resilience for the future. Operationally, the domestic maritime industry has proven resilient. That resilience can be attributed to three things:

1. The industry's historic experience with contingency planning, safety management systems, and crisis management.
2. Companies' early realization that the key to keeping vessels operating and commerce moving would be to keep mariners, who are the linchpin of their operations, healthy and safe.
3. Government/industry communication and timely implementation of practical policies that complemented the steps industry was taking to keep vessels operating and mariners healthy and working.

We could have had a total breakdown in the maritime supply chain last spring, as states and localities imposed a patchwork of stay-at-home orders. We didn't. Similarly, the Coast Guard, as our industry's primary regulator, has been proactive and collaborative in working with industry to meet regulatory objectives, while reducing health and safety risks. That cooperation has been essential to keeping the domestic maritime supply chain moving efficiently, safely, and securely.

What have we learned from this experience to date? What does it suggest for future actions to strengthen the resilience of the marine transportation system? This experience reinforces the importance of robust support from policymakers for the four pillars that undergird a healthy domestic maritime transportation industry under normal circumstances:

1. The Jones Act, which ensures that vessels moving cargo between US points are owned, built, and crewed by Americans.

[4] Lisa Ecola et al., *Rebuilding Surface, Maritime, and Air Transportation in Puerto Rico after Hurricanes Irma and Maria*, RAND Corporation, 2020. https://www.rand.org/pubs/research_reports/RR2607.html

2. A modern, well-maintained ports and waterways infrastructure. We need to increase investment in locks, dams, harbor maintenance and dredging, build the next generation of Coast Guard buoy tenders, and ensure the funding to keep them operating.
3. Uniform laws and regulations governing maritime transportation. Federal leadership is needed to ensure that a patchwork of state laws and regulations don't disrupt the efficient flow of vital maritime commerce.
4. Safety, which requires continued industry leadership and even-handed and proactive Coast Guard enforcement.

What other steps can we take, drawing on our experience with COVID, to strengthen the resilience of the marine transportation system? Again, here are four:

1. Companies can include pandemic and public health emergency planning in their safety management systems. Government can work to prioritize access to testing, PPE, and vaccines for frontline maritime workers.
2. Government and industry can work to strengthen the cyber systems that have made remote work possible.
3. The Coast Guard and other agencies can ensure they have the authority to adapt policies, procedures, and requirements to deal with emergency situations, and to enable continuing use of practices that have reduced health & safety risks during the pandemic and could improve efficiency and resilience going forward.
4. We should all discuss lessons learned, with an eye toward improving communication channels, preparing for future emergencies, and strengthening resilience.

Capt. Jason Smith (Sector Commander, Sector Houston-Galveston, US Coast Guard), Panelist

Capt. Smith drew on his Coast Guard experiences and observations to propose effective ways to ensure resiliency.

The Coast Guard supports many missions to keep the 360 ports around the country safe, secure, clean, and efficient. It doesn't do so alone, but works with federal, state, and local partners, industry, and the public.

Our success as a maritime community comes from how we perform three aspects of every mission: (1) how we analyze and prepare for risks; (2) how we respond to risks that that become events; and (3) how we recover from these events. That last one is the topic of this symposium: our ability to be resilient. And there are two

pieces to measuring resiliency: (1) how long it takes to recover, and (2) how close we eventually come to full recovery once we do get there.

Capt. Smith spoke about some events that have occurred in the maritime community. Throughout them all, he observed common threads with respect to resiliency and how we recover. Those common threads can be bucketed into three categories: (1) how resilient the port community is in returning to normal or new normal, (2) how the Coast Guard operations return to a normal or a new normal, and (3) how resilient our personnel are in returning to a normal or a new normal.

The entities that plan early on to be most resilient succeed. And those that stand by and wait for other entities to drive them to be resilient are the ones that often fail.

Another point is, how has the Coast Guard understood the needs of the industry? It comes down to communication. What do we have in place to receive, to process, and to push out information? In Houston during major events, three best practices are used. (1) At the first sign of a major event, they stand up a "port coordination team" to call that articulates the risk; it has pre-designated maritime stakeholders, who represent many aspects of the industry within the port. (2) They use Maritime Transportation Safety Recovery Units (MTSRUs); they embed maritime stakeholders into the response team to restore the port. (3) Last, they use a program called CART, the Common Access Reporting Tool, to articulate information to other incident command posts.

To have unit resiliency, it's sometimes important to shut down the unit, or particular units or assets, especially when taking shelter during the impact. That might seem counterintuitive, but if an organization has exceeded its limitations, it is best for it to preserve its assets for the time when they're needed. Also, one must immediately activate damage assessment teams to assess damage to assets and facilities. Right behind them is repair teams, so that emergency repairs can be made as quickly as possible.

The last thing Capt. Smith addressed was personnel resiliency. Early preparation in setting personnel expectations is critical. There needs to be a plan on the home front, so that members' dependents or families know that the members are first responders and will likely not be there during an event. There need to be other types of teams to support members, both logistically and financially, and even legally. Well ahead of the incident, there needs to be a training plan in place, so members are ready when an event occurs.

Notably, an entire team isn't always needed to deal with a smaller event. Compartmentalizing that team into the members that you need is critical.

And finally, mental health services must be provided to help individuals who are exposed to traumatic, or even just high-stress events, to minimize the harmful effects of the stress of the job, particularly in crisis management situations.

Takeaway:

Aaron Davenport demonstrated the importance of and need for information, both for awareness during disaster events and during recovery. Jennifer Carpenter found and highlighted successes we've had in the maritime sector, in stepping up to deliver service. Finally, Captain Smith conveyed the importance of partnerships and communication for resilience during disasters.

PANEL #7: ENERGY RESILIENCE IN THE MARITIME SECTOR

Moderator/Chair: Dr. Kristin Lewis (Principal Technical Advisor for Energy Analysis & Sustainability, US Department of Transportation Volpe Center)

Panelists: Mr. Andrew Stephens, Mr. Anuj Chopra, CDR Kate Higgins-Bloom, Mr. Daniel Gent

Panel Abstract:

For centuries, the maritime sector has supported critical supply chains around the globe. Since the industrial revolution, the vast majority of maritime shipping has been undertaken using fossil fuel energy sources. More recently, the maritime sector has begun exploring energy resilience options, including reintroduction of wind power as well as alternative fuels and other options. Energy options are becoming more diverse, and traditional fossil-based energy options are experiencing volatile availability and price issues. And as various climate change and/or carbon cost measures are implemented globally, shipping needs to think proactively about how to position the industry to be responsive to those changes. Furthermore, the recent pandemic has highlighted the criticality of maritime supply chains and the importance of resilience in maintaining flow of goods and people. This session will focus on the vision for energy resilience in the maritime sector and the importance of energy resilience in contributing to preparedness for black swan events, as well as the challenges and opportunities for investing in energy resilience.

Mr. Andrew Stephens (Executive Director, Sustainable Shipping Initiative), Panelist

The Sustainable Shipping Initiative (SSI) is focused on long-term sustainability in the shipping industry and bringing about change through thought leadership, and in leading the way above and beyond regulation: so being ahead of the game, driving change, and shining the light on what is the right thing to do.

SSI's current efforts include (1) a ship recycling transparency initiative; (2) the decarbonization of shipping, which is about moving towards low- and zero-carbon emission fuels; and (3) human side initiative, which is focused on the seafarers and is currently under development.

The ship recycling transparency initiative is focused on the end of life of vessels: responsible dismantling from a social and environmental perspective.

Decarbonization of shipping is related to energy resilience. The emissions from transport account for 14% of global CO2 emissions, and 90% of world trade moves by sea. What is shipping doing about decarbonization?

1. An initial strategy on reduction of greenhouse gas (GHG) emissions from ships (starting April 2018) is to reduce the absolute GHG emissions by at least 50% from a 2008 baseline by 2050; and the industry itself is, again, looking at how to adopt low- or zero-emission fuels over and above the regulation.
2. There are initiatives in the financial area called "Poseidon principles," led by 30 leading banks; it was launched in June 2019. It is focused on the transparency within the relationships of the banks and their portfolios that are held by shipping companies and operators to disclose their GHG emissions and to track them over time and improve. There are mechanisms within their lending agreements to incentivize or penalize performance.
3. The Getting to Zero Coalition was launched at the UN General Assembly in 2019 as a partnership among the Global Maritime Forum, the Friends of Ocean Action, and the World Economic Forum.
4. There is the Science Based Targets initiative. So far, five industry actors in the shipping sector have committed to set targets.

Then there's the question of alternative fuels. We're at an early stage, and it isn't clear which fuel or fuels will prevail in the maritime sector in the long run: various electrofuels, biofuels, liquefied natural gas, and/or electricity. The availability and the sustainability of biofuels for shipping is a key issue in resilience. SSI has just formed a partnership with the Copenhagen Business School Maritime under the Evergreen shipping project. The partnership is exploring the sustainability criteria for fuels and defining what will lead to standards and certification programs.

Mr. Anuj Chopra (VP Americas, RightShip), Panelist

The maritime industry needs to strive for zero emissions. RightShip's greenhouse gas emission (GHG) rating offers a strategic mechanism for lifting the standard and efficiency of vessels worldwide.

The GHG rating aims to increase transparency in the maritime industry by rating ships according to their energy efficiency, enabling users to make more informed decisions towards a more sustainable future. Key benefits include increased transparency in the shipping industry; it can help the maritime industry transition to a low-carbon economy through informed selection of more efficient vessels. Ship owners can benchmark their vessels against peer vessels to demonstrate the benefit of investing in efficiency. Financial institutions can reduce their risk by investing in efficient vessels, ensuring a greater return on investment.

Just to give an example of a typical fuel savings, suppose you're comparing a "B" rated and an "F" rated vessel, where B is second best and F is second from the bottom. The fuel savings can be as much as 25 %; the savings could be as much as $200,000 on a single voyage!

Industry should use all available scalable technologies to reduce our emissions. At a service level, RightShip provides tools so the industry can be more efficient and reduce its carbon footprint.

If we do not measure our emissions, then how are we going to manage them? RightShip helps its customers do carbon accounting and carbon offsetting. Resilience is the key and sustainability add to that resilience. The risk appetite of customers and stakeholders has come down as risk awareness has gone up. So RightShip helps companies manage their supply chain risk by helping them select the best vessel for them.

Mr. Daniel Gent (Energy & Sustainability Manager, United European Car Carriers), Panelist

Mr. Gent explained what United European Car Carriers (UECC) is and does, how they've responded to black swan events in the past, and what they plan to do in the future.

UECC's vision is to be the leading provider of short sea RoRo (roll-on, roll-off) transportation in Europe. They want to achieve high standards of sustainability as well as of their offerings to customers.

Mr. Gent spoke about some black swan events: how they affected UECC and how they responded.

1. *The Russian financial crisis of 2014–2017.* Russian vehicle imports dropped off a cliff; UECC had to find a way to employ all vessels, or they would have been running in tremendous losses if they simply lost 70 % of our cargo overnight. They utilized collaborations with other shipping lines to mitigate the losses.

2. *The impact on Algeria of the oil price drop in Q4 2014.* 95% of Algeria's budget comes from selling of fossil fuels, so there was a huge trade deficit. Vehicle imports were reduced from 400,000 cars a year in 2014 to 125,000 cars a year in 2016. The only way UECC could mitigate the damage to themselves was to stop the service entirely and find alternative employment for the vessels or to idle the vessels or lay them off elsewhere.

With respect to energy resilience, UECC was the first car carrier to have the world's first and largest dual-fuel liquefied natural gas (LNG) Pure Car and Truck Carriers (PCTC). They also eliminated ozone-depleting refrigerant gases several years before required, started to recycle vessels using Green Passport nearly a decade before the 2017 requirement, achieved oily water separator levels of 5 ppm (well below the legal requirement of 15 ppm), and reduced CO2 emissions by 38% per cargo ton/km and SOx by 51% per cargo ton/km between 2014 and 2019.

One way they've mitigated black swan energy risks is by diversifying the energy mix, trying to get away from using fossil fuel. In the past they would have taken fossil fuels in St. Petersburg, but now they receive LNG in Finland, Sweden, and elsewhere. They're pioneering the use of greener, cleaner fuels; one of their vessels now operates entirely on sustainably sourced biofuel. (They obtain carbon-neutral biofuel from the company GoodFuels in The Netherlands.) Reducing reliance on fossil oil is important not only from an emissions perspective, but from the risk perspective and the supply risk of a geopolitical event.

Next year they have three battery hybrid vessels being delivered, which will further reduce their reliance on fossil oil. They still use LNG, which is still a fossil fuel, but with an immediate emission reduction impact versus fossil oil. They see it as a great bridging fuel as they move towards biofuels, the success of which will require support from other stakeholders. They're also looking at how to introduce hydrogen into the fuel mix. There are early thoughts on how to move towards zero-emissions wind-powered vessels.

There's not a single silver bullet for achieving zero-carbon shipping; a variety of different solutions must come together to achieve zero-carbon shipping.

CDR Kate Higgins-Bloom (Director of the Coast Guard's Strategic Foresight Initiative "Project Evergreen," US Coast Guard), Panelist

Project Evergreen is the Coast Guard Strategic Foresight Initiative. *Strategic foresight* is not a product or a thing. It's a process or a practice that offers decision-makers new perspective. It enables them to make assumptions explicit, test those assumptions, forge new understanding, and prepare for a future that has yet to happen.

In the maritime industry, strategic foresight and thinking in a long-term way have particular value for a couple of reasons. First, leaders need to think about how to shape the future for their people. Then there are assets. Pretty much any ship that's brand-new today, in 20 years will still be in service. And the future will bring some other significant factors. Data is going to shape our environment, and in 20 years, there's going to be more of it. In climate change, no matter which models you look at, our physical environment is going to continue to change, and that's going to continue to require us to change. And last, global competition for resources, whether oil or space or influence, will continue to shape the maritime domain.

Foresight is not forecasting. "Forecasting" might, for example, model what the GDP in Ukraine might be next year, or occurrence of droughts in Sub-Saharan Africa. "Foresight" considers things like implications of continued Russian incursion into the Ukraine, or new waves of regional migration into Europe.

The Coast Guard's Project Evergreen is its longest running strategic foresight initiative; it's been around for over 20 years. It runs on a four-year cycle to help the next commandant, the incoming commandant, and that commandant's leadership team. It thinks about setting the strategic direction for the entire Coast Guard. It generates insight reports on key topics every few months. The goal is to deliver timely insights throughout the life of the project. The final product is a meta-analysis of the smaller pieces, identifying unifying themes and challenging paradoxes, and protecting against stove-piping of ideas. It should provide a set of recommendations on critical decisions that the incoming team will need to make.

Scenario-based planning is the core of Project Evergreen. Scenario-based planning is an opportunity to put groups of people into divergent futures, have them identify key challenges, and then develop potential solutions to those challenges. Then you bring together everyone's ideas and say, e.g., you over here have, in hypothetical future A, a solution to your challenges. But that solution also works in futures C and F. So that makes it a robust choice, because it's a good investment not only if the future turns out the way you think it will, but if the future turns out differently.

The point is to consider multiple alternative futures. If you don't, you run the risk of building a set of tools that only work in one future. With scenario-based planning, you can test things out and find out whether they work in a broad range of futures; you can figure out whether those investments are flexible enough to allow your organization to thrive. Considering how unpredictable the future is, it seems like a good way for organizations like the Coast Guard and others that have limited resources to make smart bets.

Some say we can create our own future if we want to. But we can't do it if we deny reality and plan only for the future that we want.

Takeaway:

There's no single silver bullet that will fix energy resilience in shipping. The options all have tradeoffs and challenges, some of which are related to supply availability, sustainability attributes, price, or safety. The panelists emphasized the need for a full-lifecycle approach to assessing costs and benefits of various energy sources and their risks.

The panel also emphasized that the perfect should not be the enemy of the good, and that we need the incremental improvements now; we can't wait for perfect solutions.

The group also noted that many of the plans that companies made for energy diversification and resilience were initiated prior to the coronavirus pandemic. But the current situation is spurring greater interest in innovation, including energy diversification.

The panelists made the case that in the past, the maritime sector has mostly been reactive to compliance requirements for things like carbon emissions. But the sector is now more focused on being proactive on sustainability and resilience. And customers, too, are looking to lead.

There are challenges related to localism and regulations that can make it difficult for ship owners. So, there's interest in finding a more harmonized approach to sustainability and energy resilience.

The panel emphasized the need for collaborative leadership and for global solutions that cross industries and boundaries.

STUDENT POSTERS

Moderators/Chairs: Shawn Malone and Andrew Tucci

Announcement of Winning Posters

This year, 40 individuals and teams participated in the poster competition. The judges all commented on the very impressive quality of the work shown by the participants.

The judges declared the following to be the top three entries:

- **FIRST PLACE (TIE):** "Advancing the State of Maritime Cybersecurity Guidelines," by Logan Drazovich, Liam Brew, and Susanne Wetzel of the Stevens Institute of Technology. They presented their concern that the current maritime cybersecurity guidelines don't provide a holistic set of cybersecurity recommendations for ship owners, operators, and designers.
- **FIRST PLACE (TIE):** "Development of a Handheld Sulfur Emission Detection Device for USCG Marine Inspectors" by Satesh Ramnath, Edhar Muradov, Christine Huang, and Amar Bindra from the City College of New York and the Stevens Institute of Technology. They discussed their research towards development of a hand-held device to provide the Coast Guard with an efficient way to ensure compliance with the new International Maritime Organization regulation that reduced the limit on sulfur content in fuel.
- **SECOND PLACE:** "Cyber Risk Assessment on Maritime Shipping," by Sebastian Churion, Grace Miguel, Nisil Patel, and Trey Robertson from the Stevens Institute of Technology and Texas Southern University, with research mentor Dr. Barry Bunin. They discussed their efforts to identify vulnerabilities in information technology and operation technology systems and create a risk assessment and mitigation plan for maritime facilities and vessels.

In addition, the following two posters were awarded "honorable mentions":

- "Institutionalizing Resilience: Insights from Assessment Initiatives at Seaports," by Ellis Kalaidjian of the University of Rhode Island.
- "Erosion of Port Operations: The Impacts of Coastal Wetland Resiliency on the Maritime Industry in Rhode Island," by Cadet Madeline Kaller and Cadet Anna Kemball-Cook of the United States Coast Guard Academy, advised by Dr. Tiffany Smythe.

PANEL #8: WRAP-UP

Moderator/Chair: Mr. Christopher Doane (Strategic Planning Officer, Assistant Division Chief, US Coast Guard Atlantic Area)

Panelists:

- **MRS Chair: Prof. David Nicol** (Director, ITI, University of Illinois)
- **Panel 1 chair: Capt. Todd Bonnar** (Branch Head, Combined Joint Operations from the Sea Centre of Excellence (CJOS COE))
- **Panel 2 chair: Capt. David Moskoff** (Professor and USCG Unlimited Master Mariner, United States Merchant Marine Academy)
- **Panel 3 chair: Dr. Joan Mileski** (Department Head of Maritime Business Administration, Texas A&M University at Galveston)
- **Panel 5 chair: Dr. Craig Philip** (Research Professor and VECTOR Director, Vanderbilt University)
- **Panel 6 chair: Dr. Henry Willis (**Director, Homeland Security Operational Analysis Center, RAND Corp.)
- **Panel 7 chair: Dr. Kristin Lewis** (Principal Technical Advisor for Energy Analysis & Sustainability, US Department of Transportation Volpe Center)

Mr. Christopher Doane asked each of the panelists to provide some opening comments, and then to address one or more of the three questions set forth below:

1. What are most important takeaways from their own panels?
2. What were their most important three to five takeaways from the entire symposium?
3. What would they recommend for a significant research topic based on the overall symposium conversation?

The below text provides a paraphrased summary of the panelists' remarks.

Capt. Todd Bonnar (Branch Head, Combined Joint Operations from the Sea Centre of Excellence (CJOS COE))

Three points from Panel 1: First, resilience must happen in layers. It happens much like concentric circles rippling out around something that needs to be protected. Second, these concentric circles require thorough stakeholder mapping and engagement: understanding how your engagement—your relationship with your stakeholders—impacts them as you're building resiliency, and any weaknesses that you might be inadvertently causing. The third one was from Dr.

Rob Huebert's presentation about the Arctic: it's that isolation is not always a negative when we're talking about resilience.

From the other panels, the takeaway was, resilience is a system of systems, and it requires a systemic approach. You need to understand how your actions or your organization's actions will impact others; you must understand the third-, second-, fourth-order effects of decisions you make. The next thing is to be aware of the benefits of nonlinear thinking; many people think in terms of linear processes, but it came out in several presentations that nonlinear thinking is quite beneficial when we're talking about resilience. Finally, trust and communication are essential elements of any plan to build, improve, or initiate actions to have resilience.

Regarding future research questions, there's a lot to delve into. From a military perspective, perhaps research is needed on how to transcend the potential to be nationalistic when you're building resilience and key infrastructure.

Capt. David Moskoff (Professor and USCG Unlimited Master Mariner, United States Merchant Marine Academy)

To give a single takeaway for each of the three panelists from Panel 2: The clear takeaway from Shell and Mr. Scalli was that the humans are their critical element. Shell tried to do the best they could to minimize all the close calls they have with human beings on board and the equipment. The second takeaway, from MIT professor Michael Benjamin, was that they put together a tremendous piece of autonomous software that's being used and being customized to meet users' needs, and that's an important function that MIT is generating. John Jorgensen of ABS looked at active risk management: to assess how much risk you're willing to accept, and, if you don't like a lot of risk, you can nail down a lot of it. It's just a matter of putting the effort and time and money into it.

Stephen Flynn talked about resilience in terms of preparing, adapting, and rapidly recovering. Various panels considered different types of resilience but were basically similar at 30,000 feet. Admiral Fossum's keynote made it clear that it's all about preparation and training and knowing what you're doing, and then planning it out, developing teamwork with the folks you'll be on board with, and so on. Regarding Stephen Flynn's remarks on preparing, it's challenging to recognize the events that lie before us against which we must be resilient. A lot of people didn't think something like COVID would happen! Trying to adapt to it didn't go too well at first; world experts were telling us "Don't wear a mask," and so on.

As far as research questions:

1. There's sea level rise and the problem of bridge collisions. Suppose a vessel currently has six inches of clearance below a bridge; if sea level rises a foot,

two feet, maybe more, it'd be nice to find out how we're going to deal with this.

2. There there's radio wave conductivity. Right now, conductivity and satellites are the way all vessels are communicating, and it's a vulnerable situation. So, until somebody figures out a way to ensure conductivity, it's problem.
3. Position, navigation, and timing are key. And the timing aspect is quite a bit more important than the position and navigation aspects. It's important to have an alternate system for timing, because if that goes out, all the world's infrastructure is going to suffer.
4. Consider solar storms like the Carrington Storm of 1859 (a coronal ejection). About eight years ago, one of them just missed us by about nine days. If we have one of these ejections, a lot of scientists say it's going to burn up all the chips on every device on that side of the Earth. So, if one of these things happens, that would be a black swan event, but we know it's coming. We just don't know when.

Dr. Joan Mileski (Department Head of Maritime Business Administration, Texas A&M University at Galveston)

The main thing that came out of Panel 3 was that resilience must be looked at through several different lenses—an interdisciplinary approach in which we think in terms of a "wicked problem" wherein things can be fixed in one area, but then that affects other areas. The panel talked about the digital aspect of the supply chain and how blockchain may help in creating resilience. It talked about how the governance of certain areas of the port, for example, can help us be more resilient. It mentioned engaging with stakeholders. It looked how we can get help from local, state, and national government to make our infrastructure more resilient to lead to a better supply chain.

But one of the main issues that no one had any thoughts about—because it takes your breath away—is the idea from the last segment: what happens if an electromagnetic pulse (EMP) comes in and wipes us out? Where is the redundancy?

To make things resilient, sometimes you need redundancies. And in maritime, there is so much focus on being efficient and cutting costs that there may be no redundancies. It would be good to start that discussion: if we had a major event, where is the backup? If we could not rely on our electronics, what would that mean? How would people be able to live, get food, go to the store for things like gasoline? There are no redundancies in some of those systems. It's a scary point.

There should be more examination of how redundancies, although expensive, may be needed to make sure that resilience is in place.

Panel 4 was not represented in the Wrap-up Panel.

Dr. Craig Philip (Research Professor and VECTOR Director, Vanderbilt University)

Takeaways from Panel 5:

1. The first is arguably a takeaway for the symposium as a whole: There is a complicated interplay between public and private stakeholders that impacts maritime system resilience in multiple ways. Local actions can be frustrated by the manner in which the core is involved. It's important to think about different modes that are going to allow various stakeholders to channel their efforts and work to effect resilience-enhancing options.
2. The maritime freight domain is always multimodal. There can be multiple intersecting maritime modes, and they almost always serve other, surface transportation modes as well. And the actors don't always play nice with each other, given the competitive dynamics that often exist in their marketplaces. But the resilience enhancements that everyone knows are needed are going to happen only if we take a true multimodal perspective.

From the symposium as a whole, a large takeaway is the ideas in the quotation "Lightning makes no sound until it strikes." We're drawn to the abrupt dramatic events that are going to draw our attention and our resilience focus. But the maritime domain also faces "leaky faucet" risks that can reach a tipping point under the radar. They can be equally disruptive and maybe have more pernicious consequences. In the case of inland infrastructure, there's decay that afflicts much of it; some of the human workforce issues may also fall into this category.

Finally, a research question that should be looked at is the structural barriers that exist between public and private stakeholders that can limit adoption of effective resilience enhancement efforts, and what we can do to overcome those barriers.

Dr. Henry Willis (Director, Homeland Security Operational Analysis Center, RAND Corp.)

In Panel 6, Aaron Davenport demonstrated the importance of information and the need for information for awareness both during disaster events and during recovery. Captain Smith, in sharing his experiences at the port of Houston,

conveyed the importance of partnerships and communication for resilience during disasters. And finally, Jennifer Carpenter was found and highlighted some of the successes we've had in the maritime sector, in delivering service.

There were similar themes throughout the symposium. Michael Meyer's talk demonstrated both the importance and challenge of sharing lessons and experiences across sectors. The Transportation Research Board brief he gave highlighted the unique role the Coast Guard plays in working in the maritime sector across the private sector, government, and with state and locals. It also highlighted how we might work with CISA as a partner, and some of CISA's work was highlighted by Jennifer Carpenter when she talked about the value of CISA's designation of critical workforce and employees, and how that's been useful for the industry as it attempted to bounce back from COVID.

A second takeaway: In the talks by Katherine Chambers and Aaron Davenport, we saw a dichotomy between the large number of tools and amount of information out there, and how that can sometimes be a mismatch with the uneven capacity of localities, e.g., smaller firms or regions, to have the financial and human resources to implement resilience planning. So, the Federal Government can play a role in support to that.

And then finally, a third takeaway from across the symposium is the importance of workforce as a linchpin to infrastructure resilience: both the resilience of the workforce in helping ensure the resilience of infrastructure, and the need for infrastructure to be resilient to help the workforce be there.

In terms of research topics:

1. The need to develop engineering design guidelines and operational planning templates for maritime resilience. Sometimes smaller regions and smaller firms need this type of technical assistance to be able to plan.
2. Are there ways to collect lessons from COVID-19 experiences to understand the distinctions between the more prolonged events vs. abrupt disasters?
3. In the context of information-sharing tools, topics, and processes, there is a need to collect more experience and lessons learned of promising practice for what are the tools that we need to spread further, what types of information we're sharing, and how we can do it more effectively.

Dr. Kristin Lewis (Principal Technical Advisor for Energy Analysis & Sustainability, US Department of Transportation Volpe Center)

A key takeaway from Panel 7's discussion of future fuels and emissions reduction technologies is that there's no single silver bullet that will fix energy resilience in

shipping. The options all have tradeoffs and challenges, some of which are related to supply availability, sustainability attributes, price, or safety. The panelists emphasized the need for a full-lifecycle approach to assessing costs and benefits of various energy sources and their risks.

The panel emphasized that the perfect should not be the enemy of the good, and that we need incremental improvements now; we can't wait for perfect solutions. Dan Gent talked about how flexibility can help a company respond to changes in supply and price. Anuj Chopra talked, e.g., about providing incentives to have shippers select more efficient vessels, and there are interesting solutions that provide a bridge to those perfect solutions or give us incremental advances that we can improve upon over time.

The group noted that many of the plans that companies made for energy diversification and resilience were initiated prior to the coronavirus pandemic. But the current situation is spurring greater interest in innovation, including energy diversification, as the sector sees the impacts that can occur if you're dependent on one system.

The panelists also made the case that in the past, the maritime sector has mostly been reactive to compliance requirements for things like carbon emissions but is now more focused on being proactive on sustainability and resilience. And customers, too, are not looking for minimum compliance anymore; they are looking for best practices; they are looking to lead.

There are challenges related to localism and regulations that can make it difficult for ship owners who might have a ship that can operate in one port but not in others because of a patchwork of regulations. So there is interest in finding a more harmonized approach to sustainability and energy resilience.

Our panelists emphasized the need for collaborative leadership on these issues and trying to find global solutions that cross industries and boundaries.

Regarding takeaways from MRS as a whole: we are now more interconnected than ever, and we're dependent on these systems of systems. That interdependency means we need collaboration, not just within and across the maritime sector, but across other sectors as well, so that we create those resilient systems of systems. And energy is certainly one of those crucial systems on which everything else relies.

With respect to future research, there is a critical issue with evaluating lifecycle benefits and impacts of alternative fueling options for the maritime sector—to help provide an understanding of not just carbon emissions reduction, but a broader

range of sustainability issues, so that we can identify trade-offs and synergies that can influence the direction of fueling choices and fuel diversification.

One area of research, which resonates with both the collaboration theme and the idea of harmonized approaches, is the fact that shipping may involve different opportunities from other sectors. But there may be synergistic approaches that we could take to facilitate deployment of new fuels that would increase the diversification of fuel supplies for the maritime sector, but also other sectors at the same time.

Takeaway:

Panel 8 highlighted the major themes gleaned from the symposium. It looked back on the great ideas that emerged in the preceding panels and keynotes, from potential research projects to focusing on the wicked problem of risk assessment and resilience.

As one participant put it, we were confronted with the fact that resilience isn't a spectator sport: you must be in the game.

PROJECT EVERGREEN

The Evergreen Program is the Coast Guard's Strategic Foresight Initiative, tasked with looking over the horizon to inform current planning and better prepare the Coast Guard for an uncertain and unpredictable future. Using scenario-based exercises and workshops involving a diverse group of stakeholders, common strategic needs or key success factors can be identified across multiple plausible scenarios to better inform long-term strategic planning efforts.

Evergreen@MRS2020 is a joint venture that combines strategy and foresight with the greater maritime community of seasoned industry professionals, academic centers and national labs, maritime students, and government/NGO regulatory bodies. At the 2020 event, hosted virtually, participants examined one of four future scenarios and identified tomorrow's maritime infrastructure vulnerabilities and their implications to prosperity and security. The teams offered a balance of diversity of experience, combining students and professionals in an interactive workshop designed to drive multidisciplinary perspectives and strategic thinking.

For information regarding Evergreen and future workshops please contact Ryan Hawn at Ryan.D.Hawn@uscg.mil.

SYMPOSIUM SPEAKER BIOGRAPHIES

Dr. Michael Benjamin

Research Scientist, MIT Computer and AI Lab
Department of Mechanical Engineering, MIT

Michael Benjamin is a Principal Research Scientist at MIT in the Department of Mechanical Engineering. His research focus is on autonomy algorithms and software for unmanned marine vehicles. In 2005 he founded an open-source project named moos-ivp.org comprising dozens of marine autonomy applications including the IvP Helm for autonomous decision making, and COLREGS autonomy on unmanned surface vessels. His software is used on many different types of unmanned marine vehicles around the world.

He received BS and MS degrees in computer science and cognitive science from Rensselaer, and MS and PhD degrees in computer science from Brown University. Prior to coming to MIT, he was a research scientist at the Naval Undersea Warfare Center and was the 2005 NAVSEA Scientist of the Year. Since the Spring of 2012 he has developed and taught a course in unmanned marine vehicle autonomy at MIT to undergrad and graduate students and has led the startup of a new laboratory facility for marine autonomy on the Charles River on the MIT campus.

Captain Todd Bonnar

Branch Head
Combined Joint Operations from the Sea Centre of Excellence (CJOS COE)

Captain Todd Bonnar, MSC, CD joined the Canadian Armed Forces as a Direct Entry Officer in 1997 after completing Maritime Surface Officer classification training in HMCS VANCOUVER in 1998, he was selected to represent Canada in an exchange with the Royal Australian Navy in HMAS HOBART and HMAS ANZAC during which time he participated in the UN Peace Keeping Mission to East Timor.

He returned to Canada's West Coast fleet in 2000 and subsequently served as the CANFLTPAC Flagship's Above Water Warfare Officer in HMCS ALGONQUIN. During this time, he deployed to the Persian Gulf in support of OP APOLLO, Canada's response to the September 11th attacks earning a Task Force

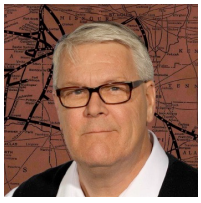
Commander's commendation for his Intelligence work. Captain Bonnar completed his Operations Room Officer course in 2004, returning to HMCS ALGONQUIN where he served as both the Flagship's Weapons Officer and Combat Officer. During this tour he also completed his Area Air Warfare Commanders qualification.

His sea command tour saw him assigned to HMCS PROTECTEUR in 2010-2014. During his time in PROTECTEUR, he participated in numerous deployments in support to counter narcotics efforts in Central America with Joint Inter-Agency Task Force (South), earned the Operational Support Medal (Expeditionary) as well as a Commander Canadian Joint Operations Command commendation.

In 2017 he represented Canada as Chief of Staff and Deputy Commander of NATO's high readiness maritime Task Group, Standing NATO Maritime Group One, participating in Operation REASSURANCE in the Baltic Sea and Operation SEA GUARDIAN, NATO's enduring counterterrorism and security operation in the Mediterranean, earning the Meritorious Service Cross and NATO Secretary General's Meritorious Service Medal for his leadership of the Task Group.

Shore duties saw him employed as J3 Current Operations at Canadian Expeditionary Forces Command in Ottawa, integrally involved with full spectrum joint operations in Afghanistan. In 2014 he assumed command of the Naval Officer's Training Centre charged with developing and mentoring the future cadre the Royal Canadian Navy's commanding officers. In 2015 as part of RCN Transformation, he assumed the inaugural command of Naval Fleet School (Pacific). Upon his return from duties at sea in Europe, he was promoted and assigned the position of Warfare Analysis Branch Head at CJOS in Norfolk, VA.

He holds a Bachelor of Social Sciences Degree from the University of Ottawa and a Masters of Defense Studies with a focus on Chinese Domestic Policy, from the Royal Military College of Canada. He is a graduate of CF Joint Command and Staff Programme 36.



Dr. Mark Burton

Interim Director, Appalachian Transportation Institute
Marshall University

Mark Burton was awarded a Ph.D. in economics from the University of Tennessee in 1991. His professional career has included both academic and consulting research in the areas of regional, transportation, and telecommunications economics. In addition to authoring

numerous articles and monographs, Dr. Burton has provided testimony in connection with a variety of judicial and regulatory proceedings. After a 15-year term at the University of Tennessee's Center for Transportation Research, Professor Burton has recently renewed his association with Marshall University's Appalachian Transportation Institute where he currently serves as Interim Director.

Mr. Rob Cannizzaro

Port of Virginia

Rob Cannizzaro is currently the Vice President of Operations for the Port of Virginia's operating company, Virginia International Terminals LLC. In this role, Rob and his team are responsible for marine, rail, yard and gate operations across the Port of Virginia's deep-water facilities in the commonwealth, handling approximately 1.5M containers annually. Prior to this, Rob spent 25 years in Ocean Carrier operations, holding roles such as Vice President of Marine and Terminal Operations, Vice President of Logistics as well as management positions in Procurement, Vessel Planning, Equipment Control and Risk Management. Rob serves on the boards of the Intermodal Association of North America and the Containerization and Intermodal Institute. Rob earned a B.S. in Marine Business and Commerce from the State University of New York Maritime College at Fort Schuyler in 1994. He later returned to earn an M.S. in International Transportation Management at SUNY Maritime in 2008 and taught graduate courses there beginning in 2012. He also holds an M.B.A. from Centenary University of New Jersey. Rob lives in Virginia Beach, Virginia with his wife of 22 years and their 16-year-old son.

Ms. Jennifer Carpenter

President and CEO, American Waterways Operations

Jennifer A. Carpenter serves as President & CEO of The American Waterways Operators (AWO), the national trade association representing the inland and coastal tugboat, towboat, and barge industry.

Ms. Carpenter joined AWO in August 1990 and became President & CEO in January 2020. Before assuming her current position, she worked her way up the hawsepipe from Government Affairs Assistant to Executive Vice President & Chief Operating Officer, holding a series of progressively responsible positions

including Manager-Regulatory Issues, Director-Government Affairs, Vice President-Government Affairs, Senior Vice President-Government Affairs & Policy Analysis, Senior Vice President-National Advocacy, and Executive Vice President. She served for 13 years as a member of the congressionally authorized Towing Safety Advisory Committee. She has received two Meritorious Public Service Awards and a Public Service Commendation from the US Coast Guard for her contributions to the Towing Safety Advisory Committee and the Coast Guard-AWO Safety Partnership.

Ms. Carpenter holds a B.S. in international relations, law and organization from Georgetown University, an M.S. in conflict analysis and resolution from George Mason University, and was a Georgetown University China Studies Fellow at National Chengchi University in Taipei, Taiwan. A native of St. Louis, Missouri, Ms. Carpenter resides in Alexandria, Virginia, with her family.

Ms. Katherine Chambers

Research Scientist, ERDC
US Army Corps of Engineers

Katherine Chambers is a research scientist with expertise in analytical approaches to resilience and the marine transportation system. For the past 6 years, she has focused on studying the concepts of resilience as they pertain to the marine transportation and emergency response business lines of the US Army Corps of Engineers. She is an active member of several international working groups on the marine and inland transportation system and a young member of the Transportation Research Board Ports and Harbors Committee, and co-leads an interagency team entitled the Resilience Integrated Action Team as a part of the US Committee on the Marine Transportation System. Katherine has an MS from Purdue University's Ecological Science and Engineering Interdisciplinary Program and a BS from Wittenberg University.

Mr. Anuj Chopra

VP Americas, RightShip

Anuj leads the RightShip team for the Americas region, focused on providing consistent service managing Safety, operational risk and sustainability of the maritime supply chain for our customers and stakeholders. Passionate to improve maritime "Safety + ESG" for the maritime industry to maintain social equity and social license. He began his seafaring career

as a deck cadet working his way up to Captain and holds a Commonwealth Extra Masters Certificate of Competency, and Shipping Management from the Indian Institute of Management, Ahmedabad. Anuj is a Fellow of The Nautical Institute and chairperson of the US Gulf Branch, an active supporter of seafarer welfare as an Ambassador for the Sailor Society, and sits on the Board of Directors of the Houston International Seafarers Center. He was elected President of the Industry Advisory Board for the Supply Chain & Logistics Technology Degree at University of Houston, and on the Board (and Treasurer) of NAMEPA – North American Marine Environment Protection Association. Anuj became a member of NOAA's Hydrographic Services Review Panel at the beginning of 2019.

Rear Admiral Donna Cottrell

Ninth Coast Guard District Commander

Rear Admiral Cottrell assumed duty as the Ninth District Commander in June 2019. She is the senior Coast Guard Commander for the Great Lakes and Saint Lawrence Seaway, an area that encompasses eight states, a 1,500 mile international border, and a workforce of over 6,000 Coast Guard active duty, reserve, civilian and auxiliary men and women.

Rear Admiral Cottrell previously served as the Director, Joint Interagency Task Force (JIATF West), the US Pacific Command's executive agent for executing Department of Defense counter-drug activities to shape the theater and disrupt transnational criminal organizations that threaten US interests in the INDOPACIFIC Command's area of responsibility.

She has also served as the Deputy to the Assistant Commandant for Capability. She was responsible for identifying and sourcing new and extended capabilities, competencies, and capacity to meet Coast Guard mission requirements. She also assisted in the development of service-wide policy for Coast Guard staffing, training and equipping.

From 2014 to 2016, Rear Admiral Cottrell served as the Thirteenth Coast Guard District Chief of Staff where she directed Coast Guard field and staff activities in Washington, Oregon, Idaho, and Montana in support of the District Commander's vision and strategy. From 2011 to 2014, Rear Admiral Cottrell commanded Coast Guard Helicopter Interdiction Tactical Squadron (HITRON) in Jacksonville, FL.

Other past assignments include Commanding Officer of Air Station Savannah, Executive Officer at Air Station Detroit, Air Operations Officer at Group-Air

Station Atlantic City, Administration Officer at Air Station Chicago, and Chief of the Information Systems Division at Aircraft Repair and Supply Center in Elizabeth City, NC. Rear Admiral Cottrell was also assigned to the Navy Helicopter Training Squadron Eight at NAS Whiting Field, FL where she served as a TH-57 helicopter flight instructor. Rear Admiral Cottrell acquired over 3500 flight hours in four different models of the HH-65 and MH-65 Dolphin helicopter.

Prior to Officer Candidate School in 1987, Rear Admiral Cottrell served as a Boatswain's Mate and Aviation Electronics Technician. After her commission, Rear Admiral Cottrell served as a Deck Watch Officer aboard the USCGC STEADFAST.

A native of Wellington, Ohio, Rear Admiral Cottrell (née Perry) graduated from Ohio University with a bachelor's degree in Education in 1982; from Embry-Riddle Aeronautical University in 1997 with a Master of Science degree in Aeronautical Science; from The Air Force Institute of Technology in 2004 with a Master of Science degree in Information Resource Management; and from the US Naval War College in 2011 with a Master of Arts degree in National Security and Strategic Studies.

Rear Admiral Cottrell's personal awards include Defense Superior Service Medal, two Legion of Merits, two Meritorious Service Medals, three Coast Guard Commendation Medals, the Global War on Terrorism Medal, and the Navy Achievement Medal.

Mr. Aaron Davenport

Senior Policy Researcher
RAND, Corp.

Aaron Davenport is a senior policy researcher at the RAND Corporation. He served as White House Special Advisor for Homeland Security and Counterterrorism, serving Vice Presidents Cheney and Biden, and Executive Officer, Counterdrug Operations, US Southern Command. He retired as a senior officer in the US Coast Guard, where he served at sea aboard six ships including command of two large cutters, enforcing international drug trafficking treaties, performing cooperative security assistance, homeland security, maritime law enforcement and joint counterdrug operations throughout the Eastern Pacific, Atlantic, Caribbean and Bering Seas. He possesses decades of experience working cooperatively with several countries addressing security operations, illegal migration, maritime law enforcement and drug interdiction, including Colombia, Central American and Caribbean nations. Davenport

completed senior executive fellowships at RAND National Defense Research Institute and Chief of Naval Operations Strategic Studies Group. He holds a bachelor's in marine sciences from the USCG Academy, and a Masters in Science in Environmental Sciences, with a certificate in Industrial Hygiene and a Minor in Hazardous Materials from UCLA. He recently served as an international expert panel member and paper presenter at the 2019 NATO Science for Peace and Security Programme, Advanced Research Workshop on Counterterrorism. Earlier research and analysis includes assessing border security efficacy in Northern Africa, the Caucasus, and an assessment of the USCG counterdrug program strategy, policy and metrics. He has written for several publications within the national and homeland security arena and is an expert on maritime and border security.

Dr. Paula deWitte

Associate Professor of Practice, Texas A&M at Galveston

Paula S. deWitte, J.D., Ph.D., P.E., is an Associate Professor of Practice in Computer Science and Engineering at TAMU-College Station and Maritime Business Administration at TAMU-Galveston where she is building the maritime cybersecurity program. She is an Adjunct Professor of Law at the Texas A&M University Law School. She is a licensed attorney (Texas) and a registered patent attorney (USPTO). She holds a bachelor's and Masters from Purdue University where in 2015 she was honored as the Distinguished Alumna in the Department of Mathematics, School of Science. She obtained her Ph.D. in Computer Science from Texas A&M University (1989) and a law degree from St. Mary's University (2008). She holds a patent on drilling fluids optimization [US Patent US 8812236 B1] and has a patent pending through the European Patent Office (currently under USPTO review) on incident response to a cyber attack in industrial control environments. Her research interests are in cybersecurity risk assessment/management, cybersecurity law/policy, and maritime cybersecurity.

Dr. Joe DiRenzo III

Director of Research Partnerships
US Coast Guard Research and Development Center

Dr. DiRenzo is a retired Coast Guard officer, who spent nine years in the Navy, in both the submarine and surface warfare

communities. In 1991 he transitioned to the United States Coast Guard and was assigned to several cutters including command of USCGC JEFFERSON ISLAND. In 1999, Dr. DiRenzo was detailed as the inaugural Coast Guard Liaison Officer assigned to the CONSTELLATION Strike Group deployed to the Arabian Gulf. In 2000 he was assigned to Atlantic Area, held seven different positions including Division Chief before rising to the Senior Advisor to the Commander for Science, Technology, Innovation and Research position. In October 2015 he moved to New London Connecticut and assumed his current position at the USCG Research and Development Center. Dr. DiRenzo is one of the most published authors in Coast Guard history. A five-time winner of the service's prestigious JOC Alex Haley award he has published over 300 articles on various maritime terrorism and port security topics. He is currently on the Board of Directors of the Department of Homeland Security Center of Excellence Critical Infrastructure Resilience Institute at the University of Illinois Champaign Urbana. He is also on the board of the Federal Lab Consortium New England Region. He is a eleven time national Co-Chair of the Maritime Risk Symposium and was the co-editor of the first ever textbook focused on maritime cyber security – Issues In Maritime Cybersecurity (Westphalia). Dr. DiRenzo is a 1982 graduate of the United States Naval Academy, holds a Master's in Business Administration from California Coast University, and is a graduate of both the Naval War College and Marine Corps Command and Staff College. He completed his Doctor of Philosophy in Business Administration (Homeland Security Specialization) in 2007 at Northcentral University in Prescott AZ. He teaches for American Military University and Northcentral University. Dr. DiRenzo is married to retired Navy Nurse Corps Captain and Operation Iraqi Freedom veteran Karen DiRenzo. They have two children Joe IV, a graduate student and Lauren an Intermediate School teacher.

Mr. Christopher Doane

Strategic Planning Officer, Assistant Division Chief
US Coast Guard Atlantic Area

Mr. Doane serves as the Senior Strategic Planner and Assistant Division Chief for Resources at US Coast Guard Atlantic Area in Portsmouth, VA. Atlantic Area has operational responsibility for the execution of Coast Guard missions across a hemispheric area of responsibility from the Rockies to the Arabian Gulf. As the command's Deputy Chief Financial Officer and strategist, Mr. Doane's work includes the development and implementation of the Area Commander's various strategic plans and using these plans as he participates in building and executing the Coast Guard's current and future budgets. He also

serves as the US Coast Guard Chair at the Joint Forces Staff College, Norfolk, VA. He has been with the Coast Guard for over 38 years as a military officer and civil servant.

Mr. Doane holds a Master of Arts in National Security and Strategic Studies from the US Naval War College, a Master of Science in Ocean Engineering from the University of New Hampshire, and a Bachelor of Science in Biological Technology from the University of Maine at Machias. He has written extensively on maritime security topics providing articles for a variety of national and international periodicals and textbooks.

Stephen E. Flynn, Ph.D.

Founding Director, Global Resilience Institute
Professor of Political Science, Northeastern University

Dr. Stephen Flynn is Founding Director of the Global Resilience Institute at Northeastern University where he leads a major university-wide research initiative to inform and advance societal resilience in the face of growing human-made and naturally occurring turbulence. He is a Professor of Political Science with affiliated faculty appointments in the College of Engineering and the School of Public Policy and Urban Affairs. Professor Flynn has previously served as President of the Center for National Policy and spent a decade as a senior fellow for National Security Studies at the Council on Foreign Relations. He has presented expert congressional testimony before the US Senate and US House of Representatives on 31 occasions. Dr. Flynn was an active duty commissioned officer in the US Coast Guard for 20 years, including two tours as commanding officer at sea. He is co-author of the textbook, Critical Infrastructures Resilience: Policy and Engineering Principles (2018), and author of The Edge of Disaster: Rebuilding a Resilient Nation (Random House, 2007), and the national bestseller, America the Vulnerable (HarperCollins 2004). In September 2014, he was appointed by Secretary of Homeland Security to serve a member of the Homeland Security Science and Technology Advisory Council (HSSTAC). He also serves as chair of the Massachusetts Port Authority Security Advisory Committee. Prof. Flynn holds the M.A.L.D. and Ph.D. degrees from the Fletcher School of Law and Diplomacy, Tufts University and B.S. from the US Coast Guard Academy.

Rear Admiral Michael Fossum

Chief Operating Officer, Vice President, Texas A&M University at Galveston
Executive Professor of Maritime Administration, Texas A&M University at Galveston

Michael E. Fossum '80 currently serves as a Vice President of Texas A&M University, the Chief Operating Officer of the Galveston Campus, and the Superintendent of the Texas A&M Maritime Academy. Fossum joined Texas A&M following his retirement from the National Aeronautics and Space Administration (NASA) — Johnson Space Center in 2017.

Fossum is a veteran of three space flights with more than 194 days in space and more than 48 hours in seven spacewalks during his 19 years as an astronaut. During his last mission in 2011, Fossum served as the Commander of the International Space Station. He has logged over 2,000 hours in 35 different aircraft throughout the course of his career. Fossum earned a Bachelor of Science degree in Mechanical Engineering from Texas A&M University and was commissioned as an officer in the US Air Force in 1980. He is also a graduate of the US Air Force Test Pilot School and has earned Master of Science degrees in Systems Engineering and Physical Science/Space Science.

Fossum was born in Sioux Falls, South Dakota, and grew up in McAllen, Texas. He is married to his Aggie sweetheart, the former Melanie J. London '80. They have four children and six grandchildren. He enjoys family and outdoor activities. Fossum has been a lifelong supporter and volunteer in the Scouting program.

Dr. Cassia Bomer Galvao

Assistant Professor, Texas A&M at Galveston

Dr. Cassia B. Galvao is an Assistant Professor at the Department of Maritime Business Administration of Texas A&M University at Galveston. She was hired in August 2017, the same year when she completed her PhD in Social Science also at the Catholic University of Sao Paulo. Her dissertation was about port policies and development in the context of economic development. While developing her academic career, she has worked in the private sector and has 10 + years of experience in Marketing & Sales in major international container shipping liners and freight forwarders. During her PhD studies, she was selected to participate at Fulbright Foundation Scholarship Program in partnership with CAPES and carried out her research at MARA/TAMUG as Visiting Scholar. Dr. Galvao has 10 + years experience in teaching International Economics; Global Entrepreneurship; Maritime Shipping &

Logistics; Port Economics & Governance; Marketing Transportation Services. In 2019, she was nominated member of the Ports and Channels Standing Committee of the Marine Group at TRB (Transportation Board, as branch of the National Academy of Sciences). Currently she serves at the IAME (International Association of Maritime Economists) Secretariat as webmaster and communications leader; and as Secretary at the TRF Board (Transportation Research Forum). In 2020, she awarded with the TAMU Montague - Center for Teaching Excellence Award for her ability and interest in the teaching undergraduates and to foster research and develop innovative teaching.

Mr. Daniel Gent

Energy & Sustainability Manager, United European Car Carriers

Joining the merchant marine at 16, Daniel Gent has been involved in shipping for nearly 20 years. First employed as a deck cadet with Maersk before entering the bunker industry with Miami-based World Fuel Services as a Bunker Broker and physical supplier. In 2008, Daniel moved to Norwegian shipping company United European Car Carriers as their Bunker Purchaser. Since the start of 2020, he has worked as the Energy and Sustainability Manager, heading up projects relating to new fuels and taking overall responsibility for the fleet energy mix.

Dr. Amir Gharehgozli

Assistant Professor, California State University, Northridge

Amir Gharehgozli is an Industrial Engineer with a PhD in Technology and Operations Management from Rotterdam School of Management. His research interests are the applications of Business Analytics and Decision Sciences in (Maritime) Supply Chain Management, Technology and Operations Management, Information Systems, Facility and Distribution Logistics, and Production Planning; in particular, studying recent innovations and technological advancements in these areas.

His research findings have been published in scientific journals including TS, EJOR, INFORMS Journal on Applied Analytics, IJPR, MEL, TRE, and MPM. He has been the associate editor of MPM, the flagship journal of international shipping and port research and reviews for top tier journals such as TS, Networks, EJOR, NRL, JORS, and COR. He has had the opportunity to put theory into practice by working in ING Bank and consulting in different industry projects in

close collaboration with Port Authorities and Supply Chain and Logistics companies.

He is currently an assistant professor at the David Nazarian College of Business and Economics at California State University Northridge (CSUN), where in recognition of his outstanding research, teaching and service work, he is awarded and appointed as the Carande Faculty Fellow.

Commander Kate Higgins-Bloom

Director of the Coast Guard's Strategic Foresight Initiative — "Project Evergreen"
US Coast Guard

Commander Kate Higgins-Bloom is the Director of Project Evergreen, the US Coast Guard's strategic foresight initiative. Kate's previous staff tours include White House Fellow and Acting Chief of Staff DHS Office of Legislative Affairs. She has held a variety of operational leadership roles, including Command Center Chief and SAR Mission Coordinator for Sector Hampton Roads, Incident Management Chief for Sector Boston, and Commanding Officer of USCGC BARANOF. Over the course of those tours, Kate specialized in leading complex security, inter-agency crisis response, and search and rescue operations. She has deployed throughout the Caribbean, Eastern Pacific, the Arabian Gulf; and to numerous domestic responses, including Hurricane Katrina.

Kate holds a Bachelor of Science in Civil Engineering from the US Coast Guard Academy and a Master of Public Administration from the Harvard Kennedy School of Government. She also served as a Federal Executive Fellow at the Brookings Institution and is a member of the 2020-2021 cohort of MIT Seminar XXI.

Dr. Rob Huebert, PhD

University of Calgary

Rob Huebert is an associate professor in the Department of Political Science at the University of Calgary. He also served as the associate director of the Centre for Military and Strategic Studies. He was appointed as a member to the Canadian Polar Commission (now renamed Canada Polar Knowledge) for a term lasting from 2010 to 2015. He is also a research fellow with the Canadian Global Affairs Institute. Dr. Huebert has taught at Memorial

University, Dalhousie University, and the University of Manitoba. He publishes on the issue of Canadian Arctic Security, Maritime Security, and Canadian Defense. His work has appeared in International Journal; Canadian Foreign Policy; Isuma-Canadian Journal of Policy Research and Canadian Military Journal. He was co-editor of Commercial Satellite Imagery and United Nations Peacekeeping and Breaking Ice: Canadian Integrated Ocean Management in the Canadian North. His most recent book written with Whitney Lackenbauer and Franklyn Griffiths is Canada and the Changing Arctic: Sovereignty, Security, and Stewardship. He also comments on Canadian security and Arctic issues in both the Canadian and international media.

Professor Kevin Jones

Executive Dean, Faculty of Science and Engineering
University of Plymouth

Professor Kevin Jones is the Executive Dean of Science and Engineering at the University of Plymouth, and the head of the Cyber-SHIP lab. Prior to joining Plymouth, he was Head of Computer Science at City University London and had previously spent several years in the Silicon Valley. His research and teaching interests cover the Trustworthiness of Complex Systems, including Cyber Security, with a focus on the Maritime domain. Kevin is a Fellow of the IMARest, IET and the BCS, and a Liveryman of the WCIT.

Mr. John Jorgensen

Chief Scientist, ABS CyberSafety

Mr. John Jorgensen is currently Chief Scientist for Cybersecurity and Software at American Bureau of Shipping (ABS). He is responsible for cybersecurity service development for marine and offshore customers, as well as related data integrity and software integrity methods development.

Jorgensen started his career as a Surface Warfare Officer in the US Navy, working as a seagoing combat systems officer and engineer, then as a command and control systems program manager, earning degrees in communications engineering and management information systems along the way. After working in ship systems acquisition at Naval Sea Systems Command, he retired from active duty, going to MITRE Corporation, where he worked in systems engineering and architectures,

then in security engineering and architectures, in complex systems of systems environments.

Jorgensen moved to ABS to be Director of IT Security in 2013 and to build a security program for the ABS worldwide enterprise. Upon development and deployment of the new security organization, he moved to the Technology Division in 2016 to take the successful methods used in ABS into the marine community. The full integration of cybersecurity, data integrity, software assurance and system test is now the foundation for his work in the cyber domains.

Dr. Paul Koola

Professor of Practice, Texas A&M University

Paul M. Koola, Ph.D., MBA is a Professor of Practice at the Ocean Engineering Department, Texas A&M University. He has a certificate in cybersecurity from MIT and was one of the founding committee members of the Maritime Technology Society (MTS) Cybersecurity & Infrastructure Committee. Dr. Koola is a US Fulbright Scholar, German Alexander Von Humboldt Fellow, and a Danish DANIDA Scholar. He comes with a wealth of knowledge from both Academia and the Industry. His greatest strengths are his experience spanning across a significant spectrum of interdisciplinary science and engineering and the management of these technology programs. He has worked on multimillion-dollar contracts with the Department of Defense, Missile Defense, Department of Energy and NASA. His current work spans a broad range of problems in computational science and engineering specifically in the use of AI and machine learning to Engineering.

Dr. Kristin Lewis

Principal Technical Advisor for Energy Analysis & Sustainability
US Department of Transportation Volpe Center

Dr. Kristin Lewis is the principal technical advisor for energy analysis and sustainability at the US DOT Volpe Center. Her work focuses on resilience in transportation; alternative fuel transportation, availability, and sustainability analyses; and environmental risk assessments. Dr. Lewis serves the head research and technical advisor to the FAA-sponsored Commercial Aviation Alternative Fuels Initiative and provides technical expertise to the FAA

as a member of the U.N. International Civil Aviation Organization Committee for Aviation Environmental Protection Fuels Task Group and as co-rapporteur of the Sustainability Certification Scheme Evaluation Group. She leads the development of the Freight and fuel Transportation Optimization Tool, a national model for assessing optimal transport of commodities in a supply chain, which has been sponsored by the FAA, the Office of Naval Research, the Department of Energy (DOE), and the Federal Highway Administration (FHWA). Dr. Lewis also leads the Tools to Augment Transportation Infrastructure Resilience and Disaster Recovery project for FHWA and the Office of the Secretary of Transportation.

Dr. Michael Meyer

WSP Consultant and Study PI

Dr. Michael Meyer is a strategic advisor for WSP, Inc. and has held executive positions in state government and academia. He has conducted over $40 million in research primarily in transportation policy and planning. He has written 31 books/book chapters and published over 300 articles on these topics. Over the last 10 years, he has focused his research and studies on transportation system resilience with particular attention on extreme weather impacts on system performance, and over the long-term potential implications of climate change on the nation's transportation system. He has received numerous professional awards for his service to the profession and research community. In 2006, he was chairman of the Executive Committee of the Transportation Research Board.

Dr. Joan Mileski

Department Head of Maritime Business Administration
Texas A&M University at Galveston

Dr. Joan P. Mileski is a tenured Professor in Maritime Business Administration and of Marine Science and the Head of the Maritime Business Administration Department at Texas A & M University at Galveston (TAMUG). She holds a PhD in International Management Studies from the University of Texas at Dallas, a M.S. in Taxation from Pace University and B.B.A. in Accounting from the University of Notre Dame. She has transportation experience with Union Tank Car Corporation. She has also been a Certified Public Accountant for 41 years. She has been awarded several grants including from the US and Texas Department of Transportation, has teaching and international

research awards, and publishes in a variety of maritime and transportation journals including Maritime Business Review, Marine Policy, Maritime Policy and Management, Maritime Economics and Logistics, World Maritime University Journal of Maritime Affairs, and the Asian Journal of Shipping. Her research activities currently include the impact on Maritime Industry firms' competitive strategy of maritime security regulations. She is a Fulbright research scholar alumnae and past President of the Women in the Academy of International Business.

Captain David Moskoff

Professor and USCG Unlimited Master Mariner
United States Merchant Marine Academy

CAPT Moskoff is a recognized expert in maritime cyber security. He is a Senior Expert Advisor to NATO's Transport Group for Ocean Shipping, Senior Advisor to the DoD's Purposeful Interference Response Team (PIRT) under US SPACE COMMAND, serves as a DoT/MARAD representative to other federal entities, has represented US DHS abroad and made numerous presentations throughout the United States and internationally by request. He is a Professor at the United States Merchant Marine Academy and has served there as Head of the Department of Marine Transportation, Assistant Academic Dean, Faculty Forum President and on a range of committees at the Academy. CAPT Moskoff has acted as USMMA POC for the USCG, USCG National Maritime Center and DOD's Defense Threat Reduction Agency (DTRA) providing midshipmen Independent Study in Maritime Security and Counter-Terrorism venues. CAPT Moskoff has chaired panels and steering groups for various external symposia, conferences and maritime-related exercises/drills.

CAPT Moskoff is also President of MARITECH, a marine consulting and maritime services firm. He has been certified American Bureau of Shipping (ABS) Surveyor, certified ABS/QE ISO/ISM third party external Lead Auditor as well as third party auditor for the American Waterways Operators' Responsible Carrier Program. He is a certified Vessel Security Officer (VSO), Facility Security Officer (FSO) and Company Security Officer (CSO). He served as the first Mooring Master at Sea-3's LPG ship terminal in New England. He has held a USCG Unlimited Master's License for over three decades and has commanded both steam and diesel ships. He has a BS in Marine Transportation (SUNY Maritime) and MS in Information Technology (AIU).

Professor David Nicol

Director, Critical Infrastructure Resilience Institute
University of Illinois Urbana-Champaign (UIUC)

Prof David M. Nicol is the Herman M. Dieckamp Endowed Chair of Engineering at the University of Illinois Urbana-Champaign, and a member of the Department of Electrical and Computer Engineering. He also serves as the Director of the Information Trust Institute (iti.illinois.edu), and the Director of the Advanced Digital Sciences Center (Singapore). He is PI for two national centers for infrastructure resilience: the DHS-funded Critical Infrastructure Resilience Institute (ciri.illinois.edu), and the DoE funded Cyber Resilient Energy Delivery Consortium (cred-c.org); he is also PI for the Boeing Trusted Software Center, and co-PI for the NSA-funded Science of Security lablet.

Prior to joining UIUC in 2003 he served on the faculties of the computer science departments at Dartmouth College (1996-2003), and before that the College of William and Mary (1987-1996). He has won recognition for excellence in teaching at all three universities. His research interests include trust analysis of networks and software, analytic modeling, and parallelized discrete-event simulation, research which has led to the founding of startup company Network Perception, and election as Fellow of the IEEE and Fellow of the ACM. He is the inaugural recipient of the ACM SIGSIM Outstanding Contributions award, and co-author of the widely used undergraduate textbook “Discrete-Event Systems Simulation”.

Rear Admiral Michael Parks

Regional CEO of the American Red Cross of Northern Ohio

Rear Admiral Michael N. Parks, United States Coast Guard, Retired, assumed the responsibilities in April 2015 as Regional Executive of the Northern Ohio Region of the American Red Cross. In this capacity he oversees five American Red Cross Chapters covering 31 Northern Ohio counties serving 5.3 million people.

From 2010 to 2013, Parks was based in Cleveland and served as Commander, Ninth Coast Guard District, responsible for leading and directing all Coast Guard operations throughout the eight-state Great Lakes region, including the 1,500-mile international border with Canada. In that capacity he led more than 6,000 active, reserve, civilian and auxiliary (volunteer) personnel at 75 operational units.

During his 35-year Coast Guard career, Parks was deployed in 2010 in support of the US Southern Command to help direct emergency response following the

devastating earthquake in Haiti, working directly with the Joint Chiefs of Staff. He also deployed in response to Hurricane Katrina in 2005, providing port security, search and rescue, and support for recovery efforts.

Other significant assignments over the past decade included Deputy Director of Operations, US Northern Command in Colorado Springs; Chief of Staff, Coast Guard Atlantic Area in Portsmouth, Virginia; and Chief of Staff/Chief of Operations Response, Ninth Coast Guard District in Cleveland. Parks also completed tours of duty on six different Coast Guard cutters, commanding four of them.

Parks is a 1982 graduate of the United States Coast Guard Academy in New London, Connecticut, where he received a Bachelor of Science degree in Government. He later earned a Master of Public Administration degree from George Washington University and was selected and attended the National War College in Washington, D.C., where he received a Master of Science in National Security Strategy and Policy. Parks is also a graduate of Leadership Cleveland, Class of 2017.

He and his wife Cynthia have two daughters and live in Bay Village.

Mr. Richard Perks

NATO Allied Command Transformation Headquarters

Rick Perks coordinates Defense Planning Integration efforts for Supreme Allied Commander Transformation (ACT) to harmonize national and Alliance defense planning activities. To implement NATO's Military Strategy, Rick is part of the core team of strategists developing NATO's Warfighting Capstone Concept. Prior to joining ACT in 2019, Rick was acting head Defense Capabilities Section in the Defense Policy and Planning Division in NATO Headquarters, developing political-military and capability-related NATO defense policy. This included the Alliance's Strengthened Deterrence and Defense Posture and associated areas such as the NATO Readiness Initiative, the Alliance Reinforcement Concept, the adapted NATO Command Structure, the Alliance Maritime Posture, enhanced Forward Presence and the Framework for the South. Prior to joining the International Staff, Rick conceptualized Smart Defense and developed an approach to military foresight analysis in ACT.

A retired Naval Officer, Rick served in the Canadian Navy for 30 years. He served in a variety of seagoing and shore-based positions including deployed operations. His experience includes command, operations and staff duties across several functional areas including Defense Policy, Strategic and Operational Planning, Naval Operations and Engineering, and Training and Education.

Rick is a graduate of the University of London with a MS degree in Engineering, Saint Mary's University with a MBA degree, the Royal Military College of Canada with a Master of Defense Studies degree, and Carleton University with a Bachelor

of Engineering degree. He is also a graduate of the Canadian Forces Command and Staff Course 31.

Dr. Craig Philip

Research Professor and VECTOR Director
Vanderbilt University

Dr. Craig Philip is Research Professor of Civil and Environmental Engineering at Vanderbilt University, and Director of Vanderbilt's Transportation Center (VECTOR).

Dr. Philip's research focus is on Maritime Systems including infrastructure sustainability, and the application of risk management tools to transportation systems, carrier safety management, and transport policy. Prior to joining Vanderbilt he was President/CEO of Ingram Barge Company, the largest US marine transport carrier. In addition to Ingram, Philip's career included work in the rail and intermodal sectors for Conrail and Southern Pacific Railroad.

He is currently Vice Chairman of the National Academy of Science's Marine Board, and on the Boards of the National Waterways Foundation and the Seamen's Church Institute. He has served as Chairman of multiple maritime groups including the AWO, NWC and NWF, was a US Commissioner of PIANC, Chaired the US Chamber of Commerce's Transportation and Infrastructure Committee and was a founding member of USDOT's National Freight Advisory Committee and the Marine Transportation System National Advisory Committee.

Dr. Philip earned his doctorate in Civil Engineering from MIT and his bachelor's degree from Princeton. He is a Board Certified member of the American Academy of Environmental Engineers and Scientists, and a member of the National Academy of Engineering.

Dr. Jagruti Sahoo

Assistant Professor, South Carolina State University

Dr. Jagruti Sahoo is an Assistant Professor of Computer Science in South Carolina State University, South Carolina, USA. She received her Ph.D. degree in computer science and information engineering from National Central University, Taiwan, in 2013. She was a Post-Doctoral Fellow with University of Sherbrooke, Canada, and Concordia University, Canada. Her research interests include internet of things, cyber

security, vehicular networks, content delivery networks, cloud computing, and network functions virtualization. Dr. Sahoo served as a member of the technical program committee in many conferences and as a reviewer for many journals and conferences. She is a senior member of IEEE.

Mr. James Scalli

Manager Maritime Assurance, Vessel Quality Assurance – Americas, Shell Trading US Company

Jim Scalli is a 1990 graduate of Mass Maritime. He then went to work for the Exxon Shipping as a 3rd Mate. He continued to sail for almost 15 years serving as permanent Chief Mate for many years and held a USCG Master's License. In 2004, Jim came ashore to work for Shell Trading US Company as a Marine Technical Advisor (MTA) and oversaw the marine operations from New York to Canada. While in this role, he became an accredited OCIMF Cat. 1 SIRE Inspector and an ISM auditor. In 2009, he transferred to Houston as an MTA for Shell and Motiva's Texas refineries. In 2011, he became the Regional Team Lead of Vessel Quality Assurance. In 2013, his role was expanded to Manager Maritime Assurance, Americas which included oversight of all 3rd party vessels, terminals, and MODUs used by Shell in the Americas. In 2019, the role was further expanded to include oversight of Maritime Health, Safety, Security, and Environment (HSSE) for the Americas.

Captain Jason Smith

Sector Commander, Sector Houston — Galveston, US Coast Guard

Captain Jason Smith assumed the duties of Commander, Coast Guard Sector Houston - Galveston in 2020. As Sector Commander, CAPT Smith serves as Captain of the Port, Officer-in-Charge of Marine Inspection, Federal Maritime Security Coordinator, and Federal On-Scene Coordinator and coordinates maritime safety and security, environmental protection, search and rescue, waterways management, and contingency planning operations for the navigable waterways from the east bank of the Colorado River in southwest Texas to 60 miles east of Lake Charles, Louisiana and 200 miles offshore to the seaward extent of the US This area responsibility encompass 5 of the nation's 20 busiest ports including Houston, Beaumont, Lake Charles, Texas City, Port Arthur, Freeport and Galveston.

CAPT Smith has held numerous field and staff assignments specializing in marine safety, security, and environmental compliance. He received his active duty commission with the Coast Guard in 1996 after serving as an enlisted reservist for 3 years.

CAPT Smith is a 1996 graduate of Maine Maritime Academy with a B.S. in Marine Transportation and a 2007 graduate of the University of Maryland with a M.S. in Systems Engineering and Reliability/Risk Engineering. He is a certified Project Management Professional (PMP) and Type 1 Incident Commander. His personal awards include four Coast Guard Meritorious Service Medals, four Coast Guard Commendation Medals, Military Outstanding Volunteer Service Medal, and other unit and team awards.

Mr. Zac Staples

Founder & CEO, Fathom5

Zac Staples is the CEO of Fathom5. Prior to creating Fathom5 Zac spent 22-years in the United States Navy as a surface officer specializing in electronic warfare. Zac's final tour was Director of the Center for Cyber Warfare at the Naval Postgraduate School where he led inter-disciplinary research teams that explored cyber capability development and invented maritime artificial intelligence tools and methodologies for understanding shipboard electronic security. While at the Naval Postgraduate School, Zac also created HACKtheMACHINE, nicknamed the "Blue Angels for Geeks", which seeks to inspire a new generation of technical talent to apply their skills to national security challenges. Zac holds a B.S. in engineering from the US Naval Academy, a Masters in National Security Affairs from the Naval Postgraduate School and is a distinguished graduate of the Naval War College.

Mr. Andrew Stephens

Executive Director, Sustainable Shipping Initiative

Andrew has a truly international background in the maritime industry, working for leading maritime service providers, in the position of Chief Operating Officer, such as Wilhelmsen Ships Service and Wallem Group, in a career which has seen him working in the UK, UAE, USA, Norway and Hong Kong. He was responsible to lead and manage business transformation, continuous improvement, integration and change management programmes, drive strategic planning and implementation

consequently delivering on improved customer satisfaction, business performance and efficiency.

After a successful period in both international groups he joined The Sustainable Shipping Initiative in August 2018, where he is responsible for leadership of the Secretariat.

Professor Leonard Waterworth

Executive Professor, Texas A&M at Galveston

Colonel Len Waterworth joined Texas A&M University at Galveston as executive professor in the Department of Maritime Administration in 2014 and Associate Director for Outreach in the Center for Texas Beaches and Shores. When not in the classroom he is focused on public education and project development of flooding and hurricane surge protection in Texas. Prior to joining the premier maritime campus in the United States, Colonel Waterworth served in the United States Army and retired after serving as the Galveston District Commander of the US Army Corps of Engineers. After a long and successful career in the US Army, Colonel Waterworth has had similarly successful leadership careers in both the private and governmental sectors as the President/CEO of Dannenbaum Engineering Corporation and the executive director at the Port of Houston Authority. Colonel Waterworth holds a Master of Strategic Studies from US Army War College a Master's of Engineering Administration from George Washington University and a Bachelor's of Science degree in Civil Engineering from New Mexico State University.

Dr. Henry Willis

Director, Homeland Security Operational Analysis Center
RAND, Corp.

Henry H. Willis is director of the Homeland Security Operational Analysis Center (HSOAC) Strategy, Policy, and Operations Program; a senior policy researcher at the RAND Corporation; and a professor of policy analysis at the Pardee RAND Graduate School. He is a recognized expert in homeland security risk management. Recent work analyzes terrorism warning indicators; border security efforts; critical infrastructure resilience; and national preparedness to chemical, biological, nuclear, and radiological attacks.

Willis is an active contributor to policy research having served as the risk management research theme leader at the DHS Center for Risk and Economic Analysis of Terrorist Events at the University of Southern California and as a principal investigator at the DHS National Center for Border Security and Immigration at the University of Arizona. Through his work he testified before Congress; served on several committees of the National Academy of Sciences; advised government agencies across the United States, Europe, Australia, and the United Arab Emirates; and published dozens of journal articles, reports, and op-eds on applying risk analysis to homeland security policy. Willis is the treasurer of the Society for Risk Analysis and has served on the editorial board of the international journal Risk Analysis.

His work in homeland security policy evolved from his work on program evaluation at the White House Office of Management and Budget and infrastructure design as a water and wastewater engineer. He earned his Ph.D. in engineering and public policy at Carnegie Mellon University.

Mr. Carl Wrede

DLR Institute for Protection of Maritime Infrastructures (Germany)

Carl Wrede heads the Strategy and Ethical, Legal and Social Aspects Research department at the Institute for the Protection of Maritime Infrastructures of the German Aerospace Center (DLR e.V.) and works at the interface between applied security research and operational security to protect technical and socio-economic infrastructures. In this context, he is particularly concerned with the legal admissibility, ethical justifiability and social acceptance of highly autonomous systems and innovative security technologies.

Before joining the renowned German research institution, he was, among other things, Head of Corporate Security of a large ship management company. In this role, he overlooked global operations of a diverse fleet of more than 100 vessels to ensure the security of several thousand seafarers. He also looks back on his personal past as a nautical officer, which gave him a very personal insight into the dangers and challenges of a highly globalized industry with very diverse security challenges. Through his involvement in the tactical training and strategic development of fire departments in the United Arab Emirates, he is familiar with the importance of social and cultural acceptance for the implementation of robust safety concepts.

Carl Wrede is a permanent member of various working groups on maritime security, cyber security of maritime systems and ethically sound technology development in the context of the European Future Combat Air System (FCAS).

Dr. Kim Young-McLear

Fellow, Department of Homeland Security
Cybersecurity & Infrastructure Security Agency

Dr. Kimberly Young-McLear is an Assistant Professor (Permanent Commissioned Teaching Staff) in the Electrical Engineering and Cyber Systems Section at the US Coast Guard Academy. She is currently a fellow at the Cybersecurity and Infrastructure Security Agency (CISA) at the Department of Homeland Security. She holds engineering and technical degrees from Florida A & M University, Purdue University, and The George Washington University (Ph.D. in Systems Engineering). Her research is focused on protecting critical infrastructure from cyber threats in the maritime domain. Dr. Young-McLear has been instrumental in advancing the Coast Guard through STEM and was selected as the 2017 Capt. Niels P. Thomsen Innovation Award for Cultural Change for her research in leveraging social media for large-scale disaster response during Hurricanes Harvey and Irma.

REPORT 2020:

11TH ANNUAL MARITIME RISK SYMPOSIUM

Understanding and Managing Risks to the Marine Transportation System

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