KEY FACTS

- The U.S. Arctic is an environmentally sensitive area with limited commercial, civil, maritime or transportation infrastructure, and great distances to traverse to access resources in the case of a maritime, personnel casualty or oil spill incident (National Academies, 2014; NOAA, 2013).
- Navigation, oil pollution and hazardous materials response resources are distributed but limited across the region, and navigational safety, security and environmental stewardship are challenging.
- Charting and hydrography, infrastructure protection and maintenance, oil spill response, search and rescue, navigation safety, icebreaking and traffic management are some of the Arctic operations made more difficult; limited sanitary, berthing, housing, and medical facilities coupled with a fragile food and water supply chain aggravate the situation for emergency response.
- Exacerbating these conditions are environmental changes that now hasten coastal erosion, permafrost melting and a dynamically altered land-sea-ice boundary, opening Arctic waters to human activity and accelerating the impact of that activity on Arctic lands, populations, wildlife and waters.
- Public interest in Arctic topics, spurred by the opening of historically ice-bound navigational passages, brings more attention and traffic to a fragile Arctic ecosystem that is home for an ancient indigenous population and its unique subsistence economy.
- The future situation of the Nation’s icebreaker fleet for USCG missions is dynamic due to:
  - Current reliance on a refurbished Polar class icebreaker as a short-term solution.
  - The Administration’s 2017 USCG budget request which includes $150 million to accelerate the acquisition of a new polar icebreaker.
- The latest USCG Authorization calls on the National Academies to conduct an assessment of the costs incurred by the Federal Government to carry out polar icebreaking missions.
- International governance of maritime operations will be enabled by:
  - Implementing the IMO’s Polar Code in 2016.
  - Universal respect for the Law of the Sea (UNCLOS)...plus US ratification.
  - Effective oversight of the Arctic Ocean by the Arctic Council.
  - The recent appointment of the U.S.’s Special Representative to the Arctic.
- The US policy on the Arctic is still evolving:
  - Failure to ratify the Law of the Sea Treaty places the U.S. at a disadvantage.
  - The USCG annual exercises, Arctic Domain Awareness/Arctic Shield, are valuable efforts.
  - The Navy’s Arctic exercises show administrative progress but is limited by a tight budget.
  - Improved area intelligence, including vessel identification, is needed.
  - The Ilulissat Declaration commits the 5 Arctic littoral nations to peaceful cooperation.
REFERENCES


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Building and Fostering A Strong Safety Culture

KEY FACTS

- The concept of a safety culture in industrial activities was heightened after the Chernobyl accident in 1986 and Piper Alpha fire in the UK sector of the North Sea 1988.

- A key element of the International Safety Management (ISM) Code adopted by the International Maritime Organization (IMO) in 1997 is to establish a safety culture in shipping companies.

- Norway’s petroleum regulations of January 2002 specify that companies must have a sound health, safety and environmental culture. This was the first such requirement in international regulations.

- In 2013, the Bureau of Safety and Environmental Enforcement (BSEE) published a “Safety Culture Policy Statement” outlining principles that oil and gas operators are encouraged to adopt.

- To focus attention on safety culture in the Outer Continental Shelf (OCS), the Marine Board hosted a Safety Culture Focus Session at its 2013 Spring Meeting.

- The offshore oil industry’s Center for Offshore Safety (COS) is working on safety culture issues in conjunction with offshore contractors and the BSEE.

- To coincide with the 2013 IMO Symposium on the Future of Shipping Safety, the International Chamber of Shipping published “Implementing an Effective Safety Culture.”

- The National Transportation Safety Board (NTSB) held a Forum on Safety Culture in the Transportation Industry in September, 2013.

- In 2013, the Coast Guard published an Advanced Notice of Proposed Rulemaking to require Safety and Environmental Management Systems for vessels engaged in offshore oil and gas operations.

- The Pipeline and Hazardous Materials Safety Administration (PHMSA) worked with industry to develop a Pipeline Safety Management Standard (API RP 1173) that includes a Safety Culture section.

- In 2014, the National Ocean Industries Association (NOIA) began issuing a “Culture of Safety” Award as part of its Safety in Seas Awards Program.

- An update to API RP 75, Safety and Environmental Management for Offshore Operations and Facilities, will be completed in 2016 and is expected to address safety culture.

- Issues to address include:
  - How to understand and explain the concept of a safety culture so that is more than a catchphrase.
  - How to meaningfully measure safety performance including “leading indicators “of safety.
- How to use accident, mishap, and near-miss data to improve safety performance.
- How to foster a “safety culture” when the “blame culture” is quite strong.
- How to get actionable information and feedback from front line offshore workers.
- How regulators and classification societies can work with industry to help improve safety culture.
- What research studies are needed to advance safety culture understanding and implementation.
- How to build a strong safety culture in a complex industry with many operators and contractors

**REFERENCES**


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Sea Level Rise and Other Climate Change Impacts on the Nation's Waterways

KEY FACTS

- Recent devastating coastal flooding resulting from extreme weather events, such as *Hurricane Katrina* and *Superstorm Sandy*, have emphasized the increasing vulnerability of critical coastal infrastructure in the United States, particularly in the context of sea level rise.

- Major areas of concern include seaports and their associated landside intermodal infrastructure; critical energy supply infrastructures (including nuclear power plants, of which two dozens are located in proximity to U.S. coastlines), and low-lying heavily developed, and urban, coastal areas.

- The inundation and waves of major hurricanes and tsunamis can potentially cause immediate destruction of both critical infrastructure and broad inhabited areas, particularly in the context of sea level rise (e.g.: the destruction and disruption caused by the recent *Superstorm Sandy* and Japanese *Tohoku* 2011 tsunami). Bathymetric changes created by severe storms/tsunamis can be debilitating to maritime traffic, particularly in the shorter-term. Large currents caused by tsunamis in and around harbors can cause hazard to navigation and pose risks to large ships.

- Climate change has led to increasing storm intensity, frequency, and a more general volatility in weather patterns. These phenomena are having profound effects on U.S. coastal areas and the inland waterway system. The recent flood and drought cycles experienced in the Midwest have had a major influence on the channel depths of inland waterways and the Great Lakes, which serve as major U.S. trade routes. For the significant fraction of the US coastline, which is erodible and directly exposed to the ocean, sea level rise will exacerbate the devastating effects of increasingly intense and more frequent storms.

- FEMA has recently released new inundation (FIRM) maps for a large fraction of the US coastline. In many areas, these were developed using newer, state-of-the-art, methods, in line with recommendations of a NRC study that had pointed out deficiencies in the former methods used (NRC, 2009). In some areas, including most of New England (FEMA region 1), older, less accurate methods were used. Some experts believe these methods have serious deficiencies, including the fact that new FEMA maps do not quantify the uncertainty associated with the analysis.

- The USACE and NOAA have joined forces to develop a new template for evaluating coastal resilience in light of climatic change; a workshop of experts was recently held by the National Academy, with Marine Board participation, to establish a dialogue with these agencies and help them improving and validating their template. Although the template and associated efforts are focused on coastal communities, it would be beneficial to also develop a template for assessing the resilience of critical coastal infrastructures such as sea ports, in the context of climate change.
• With ice coverage diminishing, Arctic shipping transits are likely to become more frequent as all nations consider this new potential global trade route. Increased traffic increases the potential for severe accidents, infrastructure failures, and oil spills in Arctic waters. Establishing and maintaining aids to navigation along new shipping routes into and through Arctic waters is likely to prove especially challenging, putting a premium on acquisition of comprehensive, state-of-the-art bathymetry within the territorial sea, and complemented by e-navigation capability.

• *Resilient America*, a new program of the National Academies of Sciences, Engineering, and Medicine, is currently engaging in a project with three pilot communities (Charleston, SC, Cedar Rapids, IA, and Seattle, WA) to help community decision makers and stakeholders mitigate risk and build resilience, including from the effects of climate change on seaports.

• The Marine Board is working with the Ocean Studies Board of the National Academies of Sciences, Engineering, and Medicine on scoping a possible study to define a framework for multi-hazard probabilistic assessment of coastal hazards.

**The Challenge:** How do we better prepare and protect the nation’s ports, terminals, intermodal and other critical infrastructures from natural disasters such as hurricanes and tsunamis. Are the current tools, analyses and products from government agencies (e.g., FEMA FIRMs maps, USACE/NOAA’s coastal resiliency template) sufficient and accurate enough to prepare for these global challenges?

**The Need:** A complete evaluation of the impact of sea level rise on the nation’s transportation infrastructure (seaports, airports, road and rail networks, power plants) and other critical infrastructures should be conducted to ensure the nation’s future economic prosperity is not threatened.

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Cyber in the Marine Transportation System

KEY FACTS

- Maritime operations are increasingly dependent upon networked flows of information. Systems using cyber domain connectivity include port management, vessel navigation, shipboard control of machinery, propulsion, steering and life support, cargo management, fuel loading, hazardous material handling, and vessel traffic management.

- Motives for threatening maritime cybersecurity exist across a broad spectrum from crime to terrorism or piracy to corporate competitor or nation-state intelligence collection to acts of war.

- The consequences of insecurity in maritime systems can threaten broad interests including economic, national security, lives of passengers, crew and the broader populace, and health of the environment. Accidental cyber failures may lead to equally severe consequences as those caused by malfeasance or attack.

- Maritime cybersecurity threats have already manifested in attacks in the U.S. and elsewhere with costly consequences:
  - Loss of ballast control aboard has occurred on a deployed oil rig.
  - Narcotics smuggling was enabled by cyber disruption of cargo handling and port security.
  - Bunkering thefts have cost millions of dollars per year in stolen fuels.
  - Port cranes used for ship to shore freight movement were disabled due to a GPS hack.
  - A large offshore oil producer had tens of thousands of computers corrupted by malware.

- The National Institute of Standards and Technology (NIST) has developed a framework for improving critical infrastructure cybersecurity in response to Executive Order 13636, issued in February 2013.

- The US Coast Guard has published its Coast Guard Cyber Security Strategy in May with three strategic priorities: defending cyber space, enabling operations, and protecting infrastructure. This strategy and its priorities are useful for the maritime industry and form a foundation for future work.
REFERENCES


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Emergency Planning, Preparedness, Response, Mitigation, Improving Resiliency

KEY FACTS

- Major events and incidents, such as the 9/11 terrorist attacks, Hurricane Katrina, Deepwater Horizon drilling rig explosion, Hurricane Sandy, and the Mississippi River flooding, will continue to occur in the U.S. As transportation infrastructure is impacted and communities are disrupted, this remains a priority issue for the Marine Board.

- Response to these emergencies will need continuous improvement with respect to processes and coordination. Finding ways to make the major U.S. systems (air, marine, ports, road, and rail transportation; energy production and pipelines; electric power grid, and other critical infrastructure systems) more secure and resilient in the face of cascading failures and disruptions is important. The frequency of major events/incidents has been rising (at least one per year), and the need for strong processes is critical.

- While prevention of these events and incidents is very important, many root cause factors are beyond the control of government officials, private sector, planners and responders. Preparedness as currently practiced focuses on a reactive rather than proactive approach and is not sufficient to deal with such major disruptive events.

- The transportation system is interconnected with water, power, energy, and telecommunications systems, and thus vulnerable to cascading failures when one or more of these systems are affected by an event.

- Advanced planning, coordination, procedures, resources positioning, and exercises are critically important to enabling effective response. Spills of National Significance (SONS) exercises have been conducted for almost 20 years but can be improved and modernized. Events and incidents that require a quick and effective response involve many Federal, State and Local agencies, which typically only interface when the emergency occurs. Roles and responsibilities to be better defined at all levels, from the Governor’s Office to State Emergency Coordinators, to local officials.

- Assets from the public and private sectors can be utilized during an event/incident but no adequate database is maintained of available assets, where they are, and how they can be accessed.
• The Marine Board examined issues relating to catastrophic events in successful workshops conducted in 2003 and 2008. It is appropriate to update this work, undertake additional activities to better understand relationships between critical infrastructure systems, vulnerabilities, interconnectedness, incident management, and the resiliency options needed to restore system capacity and functionality. Much may have changed with the recent budget pressures on those providing emergency services and new technological advances can be used to improve responses (such as in communications, unmanned aircraft, etc.).

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The Future of Navigation

KEY FACTS

- The art or practice of marine navigation is changing with the advent of new electronic technology based on precise positioning using Global Navigation Satellite (GNSS) and inertial navigation systems such as DARPA’s “timing & inertial measurement unit” (TIMU), electronic charts, real-time weather and sea state, Automated Information System (AIS), etc. E-Navigation is expected to improve navigation safety from ashore by integrating the coordination and exchange of comprehensive data in formats that will be more easily understood and used by shore-based operators and supply support services for vessel safety and efficiency.

- Training and support of electronic systems typically lags technological advances. There is rapid turnover in electronic technology implemented ashore and afloat. The future of navigation safety is uncertain in this transition period.

- Tighter integration of available observations and model predictions for water levels, waves, currents, and salinity coupled with high-resolution bathymetry has the potential to provide critical “precision navigation” capabilities for mariners in busy nearshore areas, particularly in the country’s largest ports.

- While government agencies are responsible for providing the right data in the best formats, private industry is better suited to “pull” these data into a single user-friendly interface in order to best meet the local needs of mariners, including data which will incorporate individual vessel characteristics into the precision navigation deliverables for under-keel clearance.

- eLORAN remains a viable, cost-effective potential back up for GPS, but it is currently the only non-satellite Positioning, Navigation, and Timing (PNT) system that has been tested and can provide a multi-modal back up for the PNT services GPS provides. Given the growing importance of and dependence on PNT services, it is increasingly cost-beneficial to provide backup capability to those services. Both houses of Congress have requested the DOD and DNI to work with the National Research Council to study and determine options for responding to the issue of the security of space systems.

- The cost to maintain physical aids to navigation is increasing and in some cases very difficult to implement, like in Arctic waters, and the USCG working on alternative to physical aids.
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RESOURCES
USACE e-Navigation Projects

- Lock Operations Management Application (LOMA) - http://chl.erdc.usace.army.mil/Media/1/2/2/LOMA_1.0.pdf


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Human and Intellectual Capital

KEY FACTS

- Vessels and offshore platforms come in all sizes, configurations, and means of powering, with increasingly complex designs and technologies. This requires skilled naval architects, marine, ocean, and allied discipline engineers to design and build them and competent and qualified sailors to operate them.

- Because the U.S. is no longer a major shipbuilding nation, the critical mass of expertise and research in this field is at risk in this country, as is the capability to innovate. One important reason for this is, because of the limited prospects for jobs in the U.S. domestic market, fewer U.S. students are electing to study those traditional fields as a major, especially at the graduate level. This has serious implications not only for commercial ships, but also for innovative naval ship designs where U.S. citizenship is a prerequisite.

- In other sectors of the maritime industry such as offshore oil and gas exploration and production, maritime security, regulatory monitoring and enforcement, harvesting of marine renewable energy, and coastal protection, the demand for a skilled workforce capable of supporting the long term needs of the industry, in the broadest sense, is outpacing the supply.

- There is a need to refocus national efforts on maritime education that can help the U.S. regain a leading role with respect to innovation. Technical innovations designed to make ships more efficient and safer and offshore rigs capable of exploring in deeper waters and in harsh environments result in the need to have a more educated, highly trained, and skilled seagoing and offshore workforce. Similarly, the related regulatory enforcement agency workforce of the shipping and offshore industries (e.g., USCG, BSEE) needs to be equally educated, trained, and skilled to perform their mission.

- Two aspects of Human & Intellectual Capital can be considered: 1) Development through education (e.g., universities, maritime academies) to ensure a pipeline of new qualified personnel in the profession; and 2) Training and continuing education (e.g., via on-line, professional societies, company in-house) to ensure personnel are up-to-date with the latest knowledge/training. The most effective education and training programs currently available reside within certain companies, government agencies, professional societies, maritime academies, and universities.

- In this regard, the Office of Naval Research (ONR) recently reached out to a number of U.S. institutions offering programs that could be regrouped under a “Naval Engineering” education and research umbrella, to strengthen research ties, and maintain key expertise in the nation.

- Federal and state maritime academies and universities offering naval architecture, marine, ocean, and allied engineering programs need to tailor their curricula to the new realities of available job opportunities, which are less deep sea and more inland, near coastal, and offshore oil field related.

- There are numerous workforce training and continuing education programs including on-line learning, classroom training, simulation training, and virtual reality training that are currently available (or could be available) in the maritime industries.
Many universities have plans to hire instructional staff, either on a full time or part time basis, from the senior ranks of companies in order to provide more hands-on training and offer a broader range of certificate programs.

There is a need to promote, leverage, and improve access to the best education and training programs. Furthermore there is a need to identify and address any critical gaps in the suite of available programs. This will require high-level coordination and collaboration between affected stakeholders.

REFERENCES


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Marine Incidents and Near-Miss Database

Key Facts

- As marine safety standards move towards more performance and risk-based ones, it is essential that more and better data on casualties, accidents, and near-misses be captured and analyzed with the view to improving the safety of people, property, and the environment.

- There exist marine casualty databases like the US Coast Guard’s *Marine Information for Safety and Law Enforcement database*, which provides details about marine casualty and pollution incidents investigated by Coast Guard offices throughout the United States. Internationally IMO has been active in developing the *Global Integrated Shipping Information System*, a module of which includes a searchable database of maritime casualties and incidents, as well as full marine safety investigation reports submitted to IMO by reporting Administrations. Other organizations such as IHS Fairplay, UK Marine Accident Investigation Branch, Australian Transport Safety Bureau, and Transportation Safety Board of Canada also maintain marine casualty and incidence databases. Classification society DNV also has a very robust accident database that the cruise industry has used in assessing risk.

- The US Department of Interior’s Bureau of Safety and Environment Enforcement (BSEE) maintains data on incidents associated with US Outer Continental Shelf oil and gas operations. Other offshore safety regulators (e.g., Norway, UK, Australia, Brazil) maintain data on incidents in their jurisdictions. Industry trade associations publish summaries of incidents that are voluntarily reported. SINTEF (Norway) maintains a large international incident database.

- What is lacking in these databases is complete and consistent reporting of data, and in particular data on near-misses. Such reporting depends on the willingness of companies to use a common reporting system and to report the causes of failures and near-misses, which may be inhibited by concerns about legal liability or litigation among involved parties. Although required to be reported, the frequency of near-miss reporting is however dependent on a company’s safety culture.

- The U.S. aviation system has an incident reporting system with many of the features that are desirable for the maritime industry. It is maintained by NASA independent of the Department of Transportation and allows for confidential reporting.

- BSEE has recently launched a new SafeOCS program to collect and analyze reports of near-miss incidents in the Outer Continental Shelf (OCS). SafeOCS is a voluntary and completely confidential system, in which the Bureau of Transportation Statistics (BTS) collects and analyzes near-miss reports submitted by individual OCS workers, companies, and others. The system is now on-line at https://near-miss.bts.gov/ and will expand the ability of BSEE and the offshore oil and gas industry to capture essential information about accident precursors and potential hazards associated with offshore operations.
• The Center for Offshore Safety, an industry organization established in 2011, has developed a voluntary incident and near-miss reporting system with the intent of sharing data on key safety performance indicators (SPI) and identifying potential opportunities for improvement. The SPI used in this program were selected from assessments of major hazards in the offshore industry. Most of the SPI are outcomes or consequences of the failure of prevention programs and mitigations. The program will increasingly focus on preventive barriers and activities that measure proactive management performance.

• Other confidential systems also exist, including those under the US Nuclear Regulatory Commission and the Institute of Nuclear Power Operations (INPO) and a program also operated by NASA in partnership with the Federal Railroad Administration (FRA) and the railroad industry. Such examples could inform the design of a system that would work in the maritime industry.

• MARAD is supporting, through the Ship Operations Cooperative Program, an initiative with ABS and Lamar University to develop an ASTM document to assist industry with benchmarking and trending of near misses. The primary means to achieve these objectives are to promote consistency amongst the nomenclature, reporting taxonomies, and type of data collected and reported. The goal is to streamline the reporting process yet still be sufficient for industry to achieve its benchmarking and trending intentions. It is proposed that this effort will result in an ASTM Best Practices documents.

• The US Navy has a hazards, near misses and mishaps reporting analysis system that is maintained by the Naval Safety Center in Norfolk, VA.

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Risk Analysis and Predictive Analytics

KEY FACTS

- Maritime safety standards and practices are increasingly becoming risk-informed and performance based.
- Risk analysis, as a subset of Predictive Analytics, is generally viewed as a systematic way for identifying potential safety concerns, and a rational basis for prioritizing decisions and action to improve safety of people, property, and the environment.
- Methods and applications of risk analysis have advanced significantly over the past two decades with a number of industries and governmental bodies leading the way, primary examples being the U.S. Nuclear Regulatory Commission, Federal Aviation Administration (FAA), and the National Aeronautics and Space Administration (NASA).
- Risk assessments in these sectors are often comprehensive in scope, rigorous in application of advanced modeling and computational techniques, and rich in insights and practical value for supporting the design, operation, and a variety of safety oversight activities.
- The situation in the maritime industry is far less satisfactory as there is a wide range in how and why risk assessments are performed, and in their quality and effectiveness for the intended use. A main reason is the lack of commonly accepted guidelines, established good practices, and familiarity with advancements in methods for risk analysis and risk management.
- Also absent is the recognition that model-based risk frameworks can form the foundation and act as a common thread in a number of other important activities such as:
  - Analysis of Hazards (identification and ranking)
  - Accident/Incident Analysis (assessment of risk significance and identification of root causes)
  - Safety/Risk Indicators (identification of the optimum set of leading and trailing indicators and quantification and tracking of related risk metrics)
  - Safety Culture Assessment (relating safety culture factors to overall safety performance metrics)
  - Near Miss Data Collection and Analysis
  - Design and Implementation of Safety Management Systems
  - Resilience Assessment and Enhancement (systematic identification of system vulnerabilities and recovery potentials)
- For instance, a risk model can provide the framework for designing a near-miss database model for more effective and targeted data gathering, consistent evaluation of safety significance of observed events, and reduction of uncertainties in subsequent risk assessments.
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Aging Infrastructure and Inadequate Revenues

The aging infrastructure of coastal ports and inland waterways threaten the health of the U.S. economy in terms of jobs, the cost of transporting goods, and economic competitiveness in global markets. The American Society of Civil Engineers estimates that infrastructure investment needs in the ports and inland waterway sector will total $30 billion prior to 2020. This is compared to only $14 billion in planned expenditures, leaving an investment gap of nearly $16 billion. Concerns about the resiliency of the network serving international goods movement are growing, and the infrastructure investment gap will likely be further widened by the effects of climate change and sea level rise.

There are a number of ways that the Marine Board could assist. The Board could conduct a review existing studies that evaluate port and maritime infrastructure needs and develop a prioritization tool or set of metrics that would assist in identifying projects with the greatest potential impact for the investment made. Additionally, on behalf of a sponsor agency, the Marine Board could evaluate the possibility of using Public Private Partnerships as a means to fund infrastructure improvements.

New Energy Options

The advent of hydraulic fracturing of shale structures presents opportunities for the abundant use of liquefied natural gas (LNG) and other petroleum liquids (NGLs). LNG and NGL’s are used in over-the-road vehicles and in ships in Northern Europe. There are three containerships under construction and one recently completed for the Jones Act trades that are dual fuel (LNG or diesel fuel) powered. Offshore supply boats, fueled by LNG, have been put in service in the US Gulf. Methanol, a NGL, is now used as a marine fuel in ships operating in Scandinavia and costs for converting ships to methanol fuel is quite competitive compared to LNG conversion. Other NGL’s fuels such as ethane and ethylene are also being considered as marine fuels.

The North American Emissions Control Area (ECA) now requires ships reduce their emissions when calling North America Ports. Most ships have not as yet determined a permanent efficient and economical solution to meet the new standard. LNG and other NGL’s are environmentally-friendly and would conform to current and future emissions IMO regulations. The current low price of oil is also impeding investment in conversion to natural gas.

The Marine Board has identified a list of impediments to the adoption of natural gas as a marine fuel including: limited fueling stations, fuel storage space both ashore and afloat, higher initial costs to implement which limit payback periods, and a general lack of refueling infrastructure such as bunker barges along with an unclear regulatory environment.
As maritime LNG infrastructure plans are being discussed and formulated for the U.S., the Marine Board could bring together all of the relevant stakeholders, including ship-owners, ports, LNG providers, regulators, and industry organizations, to discuss some of the issues in a workshop related to developing the necessary LNG infrastructure for shipping. This would include such topics as: bunkering regulatory framework, safety, training, technical and operational aspects in using LNG for ship propulsion.