



U.S. FEDERAL ACTIVITIES ANALYZING MARINE TRANSPORTATION SYSTEM RESILIENCE

REPORT OF THE MTS RESILIENCE INTEGRATED ACTION TEAM

January 2016

Introduction

In September 2014, the U.S. Committee on the Marine Transportation System's (CMTS) Coordinating Board established the Marine Transportation System (MTS) Resilience Integrated Action Team (Resilience IAT). The mission statement for the Resilience IAT directs the team to identify opportunities for interagency collaboration and to facilitate strategies and activities to enhance MTS resilience against vulnerabilities. These may include factors such as climate change, extreme weather, global and domestic markets, and their effect on existing and future MTS infrastructure and operation. The Resilience IAT presently includes over 45 members from 12 CMTS member agencies (Table 1).

To guide the development and implementation of a work plan, the Resilience IAT uses the general definitions of resilience as proposed by the National Academy of Science in their report, *Disaster Resilience: A National Imperative*¹, and the Presidential Policy Directive 21: Critical Infrastructure Security and Resilience²:

- The ability to prepare, resist, recover, and more successfully adapt to the impacts of adverse events.

Before the Resilience IAT could develop recommendations to incorporate the concepts of resilience into MTS governance and operation, it was necessary to examine the term “resilience” and define ongoing work that was applicable within each agency, and what viewpoints needed to be considered in advancing MTS resiliency. It was evident in early discussions that there were numerous interpretations and applications of resilience as it related to the MTS and to individual agencies.

For example, the US Army Corps of Engineers (USACE) evaluates risk of coastal inundation and storm damages while also addressing aging infrastructure, studies that directly address the capacity to *resist* and *recover*; the National Oceanographic and Atmospheric Administration (NOAA) is increasing availability of climate change observations and engages with local coastal communities, thereby improving *preparations* for present-day and future changes; the US Coast Guard (USCG) facilitates trade in a changing maritime marketplace, which provides information with which to track *recovery* following storms and other disruptions; and other agencies serve complementary roles in managing, monitoring, and advancing safety, environmental integrity, and economic viability of the MTS. To better understand and organize each agency's contribution to resilience of the MTS, the team compiled resilience factors and associated agency activity, as summarized herein.

¹ Cutter, S.L., J.A. Ahearn, B. Amadei, P. Grawford, E.A. Eide, G.E. Galloway, M.F. Goodchild, H.C. Kunreuther, M. Li-Vollmer, M. Scloch-Spana, S.C. Scrimshaw, E.M. Stanley, G. Whitney, M.L. Zoback. 2013. Disaster Resilience: a National Imperative. *Environment: Science and Policy for Sustainable Development*, 55:25-29, <http://www.tandfonline.com/doi/abs/10.1080/00139157.2013.768076?journalCode=venv20>.

² The White House, Presidential Policy Directive 21: Critical Infrastructure Security and Resilience (PPD-21). February 12, 2013, <https://www.whitehouse.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil>.

Table 1. Participating CMTS Resilience IAT Members as of January 2016

U.S. Army Corps of Engineers (USACE) Co-lead
National Oceanic and Atmospheric Administration (NOAA) Co-lead
U.S. Coast Guard (USCG)
U.S. Department of Energy (DOE), Office of Energy, Policy, and Systems Analysis
U.S. Department of Homeland Security Infrastructure Protection (DHS-IP)
U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement (DOI/BSEE)
U.S. Department of Transportation (DOT), Office of the Secretary
U.S. Environmental Protection Agency (EPA)
Federal Maritime Commission (FMC)
International Trade Administration (ITA)
U.S. Maritime Administration (MARAD)
U.S. Transportation Command (TRANSCOM)

Development of the “MTS Resilience Factors Matrix”

To better understand the breadth and scope of resilience issues within the MTS, the Resilience IAT utilized member agency input to develop a comprehensive list of present and potential future hazards and constraints (hereafter, “resilience factors”) into a MTS Resilience Factors Matrix. An eight member agency team (NOAA, MARAD, USACE, BSEE, EPA, TRANSCOM, DOE, and DHS) identified thirty-one factors that relate to the environment (e.g., tidal extremes, storm frequency, invasive species, etc.) and 40 factors that pertain to non-environmental issues (e.g., economics, labor, competing use of the MTS, etc.). These factors were then divided into broad categories as summarized in Tables 2 and 3.

The second step for the Resilience IAT was documenting the types of agency engagement within each factor as a way to verify which topics have the greatest interest and momentum for MTS Federal agencies. The MTS resilience factors with the most federal activity were used as a proxy for identifying factors with greatest need, and, subsequently, the most promising focus area for future work within the Resilience IAT. Table 4 lists the variety of possible activities identified.

Table 2. Environmental factors within the broad categories of Extreme Events, Climate Change, Operations, and Species.

Environmental Factors*			
Extreme Events	Climate Change	Operations	Species
<ul style="list-style-type: none"> • Water level extremes • Tidal extremes • Frequency and severity of storms • Extreme precipitation • Extreme heat/thaw • Extreme cold/ice • Seismic disruptions • Tsunamis • Tornadoes • Volcanic activity • Wildfire • Waves • Coastal and riparian erosion 	<ul style="list-style-type: none"> • Water level/ inundation/ surge • Arctic shipping routes opening • Frequency and severity of storms 	<ul style="list-style-type: none"> • Navigation and channel shoaling • Corrosion • Inland waterways/ river conditions • Hazardous debris • Silting • Spill response capabilities • Visibility • General changing sea conditions • Ice • Solar weather 	<ul style="list-style-type: none"> • Invasive species • Threatened and endangered species and protected habitats • Subsistence fishing • Changing migration patterns • Nuisance species

**Some factors are repeated between categories because of their relationship to the category heading.*

Table 3. Non-environmental MTS resilience factors that fall under the broad categories of Logistics/ Operations, Infrastructure, Government/Policy, Technology, Security, and Energy.

Non-Environmental Factors					
Logistics/ Operations	Infrastructure	Government/ Political	Technology	Security	Energy
<ul style="list-style-type: none"> • Larger vessels • Hazardous materials/ oil spills • Emergency response capabilities • Industrial accidents • Maintenance and upkeep • Operational disruptions • Throughput • Personnel/Labor challenges 	<ul style="list-style-type: none"> • Competing demands for space of multimodal systems • Aging infrastructure • Port congestion • Lock and dam features • Levee breaches • Intermodal connectors 	<ul style="list-style-type: none"> • Community/ environmental justice • Competing uses of land/ocean/coastal areas • Regulatory/ political/ budgetary • State and federal funding • Trade relations • Distribution of management for MTS • Ship alliances • Jurisdictional conflicts • Coastal management 	<ul style="list-style-type: none"> • Cyber disruptions • Proprietary data • Electromagnetic spectrum disruption • Navigation system failures • Greening of the fleet 	<ul style="list-style-type: none"> • Terrorism • Criminal activity • Piracy • Law enforcement 	<ul style="list-style-type: none"> • Electric/ power disruptions • Marketplace drivers • Energy availability • Limited alternative fuel options • Operational redundancy • Energy infrastructure redundancy • Vessel capabilities • Changing offshore resource use

Table 4. Examples of MTS Federal Agency activities or engagements that were identified for each of the Resilience Factors.

Federal Agency Activities
Data and physical monitoring – <i>ongoing data collection (for example wave buoys, satellite, LiDAR, Automatic Identification System)</i>
Numerical models and studies – <i>R&D activities or ongoing models that provide information</i>
Defined and studied metrics – <i>metric intended to measure or evaluate the particular factor</i>
Existing tools – <i>community facing or Operations and Maintenance tools</i>
Studies with spatial domain – <i>study of a particular region (e.g., North Atlantic Coast Comprehensive Study, Mississippi Coastal Improvement Project)</i>
Operations
Programs
Partnerships
Outreach activities
Policy development
Other

Analysis and Results of Agency Input to MTS Resilience Factors Matrix

The goal of developing the MTS Resilience Factors Matrix was to understand both the scope of interest among Resilience IAT members for resilience issues and to identify which resilience factors involve the most ongoing work from member agencies as an indicator of good avenues for future work and collaboration. To analyze the matrix, co-leads quantified each agency’s participation within each resilience factor based on the previously mentioned 11 Agency Activities (Table 4). The graphical results of the matrix exercise can be found in Appendix A on the U.S. CMTS website (<http://www.cmts.gov/Activities/ActionTeams.aspx>), including groupings of each resilience factor into broad subgroups for both the Environmental and Non-environmental categories. These results highlight the areas in which there is a lot of interest over a broad number of agencies within the Resilience IAT.

For more information about the specific activities of each agency, please refer to the full matrix document, which can be found in Appendix B (<http://www.cmts.gov/Activities/ActionTeams.aspx>).

Table 5 is a group of high-priority factors from both environmental and non-environmental categories that were chosen by limiting the list to factors that had the following two criteria:

1. Active engagement from 5 or more member agencies
2. A total sum of activities ranking in the upper quartile of the category (>25 activities for Environmental Factors, >21 activities for Non-environmental Factors)

Table 5. MTS Resilience Factors from Environmental and Non-environmental categories that include active engagement from five or more MTS Federal Agencies with a total sum of agency activities found within the upper quartile of their category.

Environmental Factors	Non-Environmental Factors
Water level/ inundation/ surge (7 agencies, 38 activities)	Infrastructure resilience (7 agencies, 37 activities)
Water level extremes and long term change (7 agencies, 36 activities)	Emergency response capabilities (7 agencies, 34 activities)
Invasive species (5 agencies, 39 activities)	Regulation/ political/ budgetary (6 agencies, 29 activities)
Threatened and endangered species (5 agencies, 39 activities)	Hazardous materials/oil spills (5 agencies, 32 activities)
Changing migration patterns (5 agencies, 28 activities)	Competing uses of land/ ocean/ coastal areas (5 agencies, 26 activities)
	Larger vessels (5 agencies, 23 activities)

By mutual agreement, the Resilience IAT decided that “Infrastructure Resilience” was the clear priority among the IAT agencies, having a large number of agencies involved and the greatest number of activities.

Infrastructure Resilience is defined as the capacity of physical and technological elements of the MTS (*including built structures, natural features, navigation channels, data and information*) to resist damage, recover from, and more successfully adapt to the impacts of adverse events (CMTS-Resilience IAT Terms of Reference, 2015). Infrastructure Resilience is a broad topic that encompasses work in many different arenas, so members recommended that the effects of other environmental and non-environmental resilience factors on Infrastructure Resilience should be considered to develop short and long-term action items. Future Resilience IAT activities will focus on Infrastructure Resilience but also consider other priority factors listed in Table 5 that could affect the resiliency of MTS infrastructure.

Future Work

Moving forward, the Resilience IAT intends to build upon the identified priority of Infrastructure Resilience, but future actions must also consider how this priority can be integrated into a systems-approach that includes both environmental and non-environmental factors, meets the needs and individual priorities of member agencies, and can accommodate the variable time scales and processes for each factor (e.g. political and budgetary concerns versus long-term climate change and sea/lake level change). Not only do Resilience IAT member agencies focus on both environmental and non-environmental issues, the MTS faces a myriad of resilience factors that may be classified as “internal” and “external.”

Internal factors exist, occur, or are found within the MTS and include budgetary, political, and labor constraints. External factors are defined as occurring or acting from the outside of the MTS, and can often require an action or response. External factors include both natural and anthropogenic hazards and can be found along with internal factors in Figure 1a, b. In order for federal agencies to address both internal and external factors, they must develop an understanding of how these factors affect the MTS.

The Resilience IAT intends to further develop the Resilience Factors Matrix presented in this study by identifying the agencies that are most active in data and physical monitoring, numerical models and studies, defined metrics, and existing tools for each factor and developing a database of these efforts to further inform MTS resilience. These results will further guide collaboration on characterizing and quantifying MTS resilience through metrics and indicators for factors related to Infrastructure Resilience.

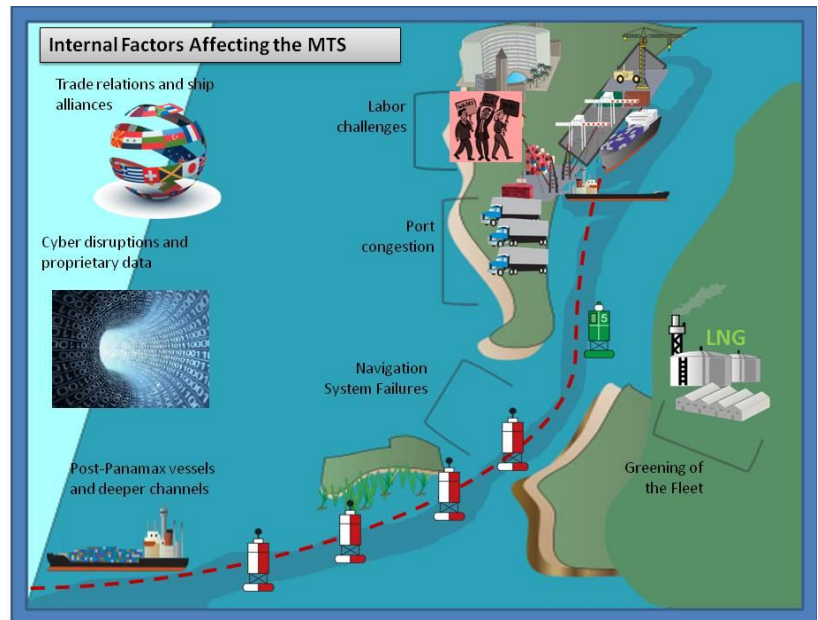


Figure 1a. Internal factors influencing the resilience of the Marine Transportation System

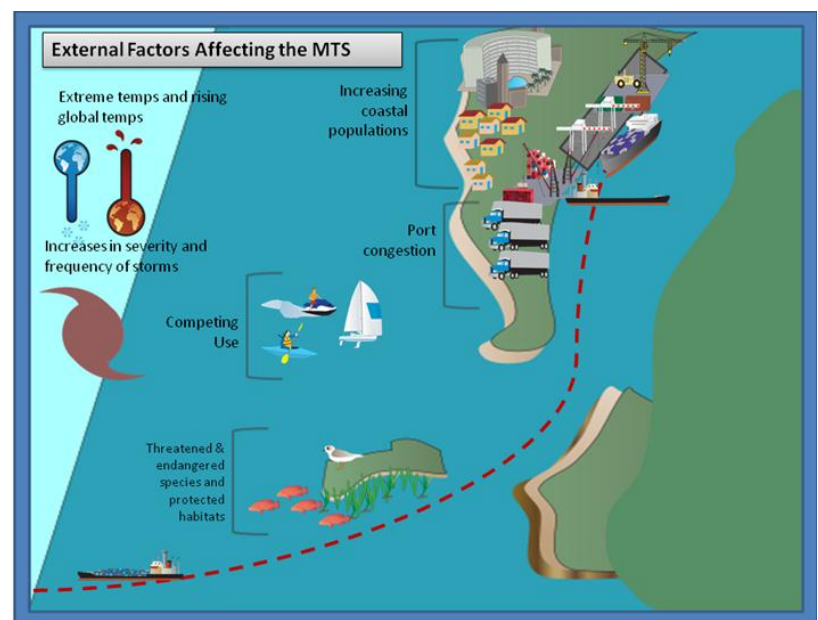


Figure 1b. External Factors Influencing the resilience of the Marine Transportation System

Appendix A. Analysis of Environmental and non-Environmental Resilience Factors

The following data are calculated from the responses of the following Resilience IAT agencies: National Oceanic and Atmospheric Administration (NOAA), U.S. Maritime Administration (MARAD), U.S. Army Corps of Engineers (USACE), U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement (DOI/BSEE), U.S. Environmental Protection Agency (EPA), U.S. Transportation Command (TRANSCOM), U.S. Department of Energy (DOE), and U.S. Department of Homeland Security (DHS).

1. Environmental Resilience Factors

The Environmental Resilience Factors category of the Resilience Factors Matrix tallied a total of 569 individual agency activities and revealed that among Resilience IAT agencies, there are four with the most focus on environment-related resilience issues: NOAA, EPA, DOI, and the USACE. Several agencies involved in the IAT helped to define resilience factors for consideration but did not contribute to populating the MTS Factors Matrix with information about specific activities. These agencies were left out of the analysis. Overall, the Environmental Extremes subgroup received the largest number of responses for agency activities (total n=208) with NOAA (n=81), the EPA (n=44), DOI (n=37), and USACE (n=21) leading the way for greatest involvement within that subgroup. Five factors emerged as priorities within the Environmental Resilience Factors category because they were in the upper quartile for number of activities and had more than 5 agencies actively engaged. Water Level Extremes and Climate-related Water Level /Inundation/ Surge were the only resilience factors with involvement from seven of the eight responding agencies; and Invasive Species, Threatened and Endangered Species and Protected Habitats, and Changing Migration Patterns followed close behind with 5 agencies involved but with a large number of individual activities. Each of these factors could be considered a candidate topic area for the Resilience IAT to develop action items and coordinate among members, especially Water level/Inundation/Surge, which received the highest breadth of involvement from seven agencies and amount of participation (38 activities). The graphs below quantify agency involvement on the y-axis (with a maximum of 10 Agency Activities) with each individual MTS Resilience Factor listed along the x-axis. Within this broad category, it is easy to see that NOAA, EPA, and DOI were highly involved in almost every individual factor, but the top priority factors identified by the Resilience IAT also had a high level of involvement from a broader breadth of agencies including USACE, MARAD, DOE, and TRANSCOM.

Figure A.1 Environmental Factors: Environmental Extremes

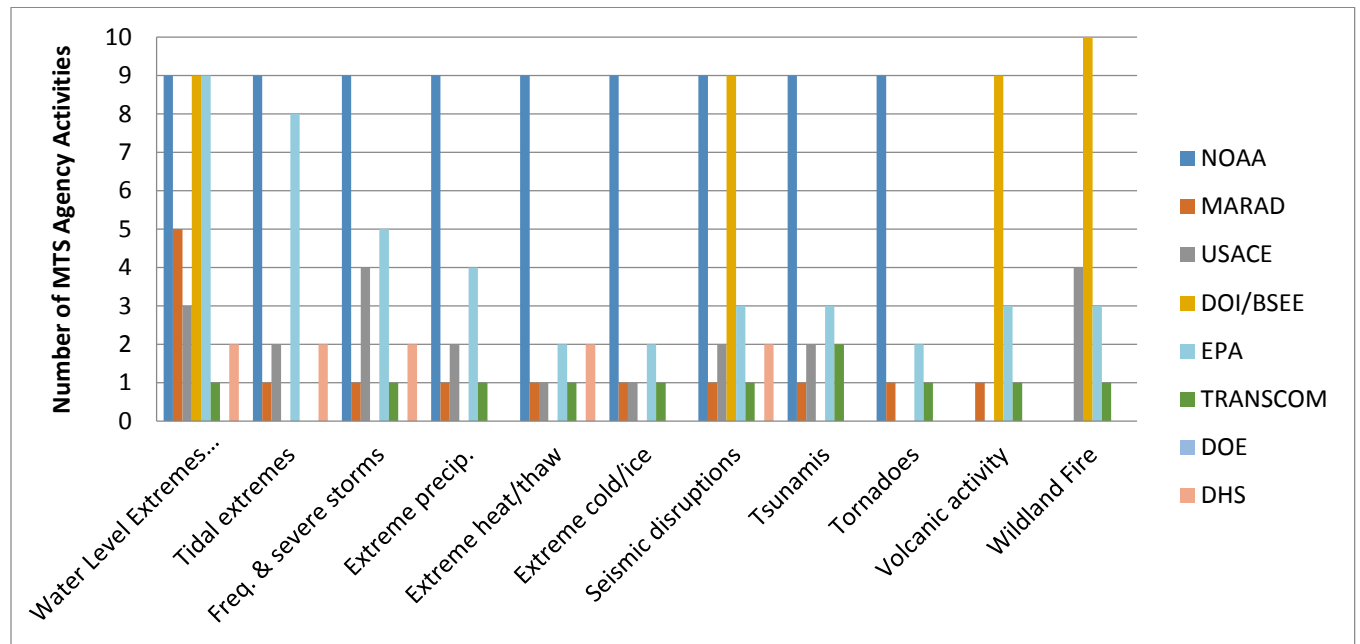


Figure A.2 Environmental Factors: Climate Change

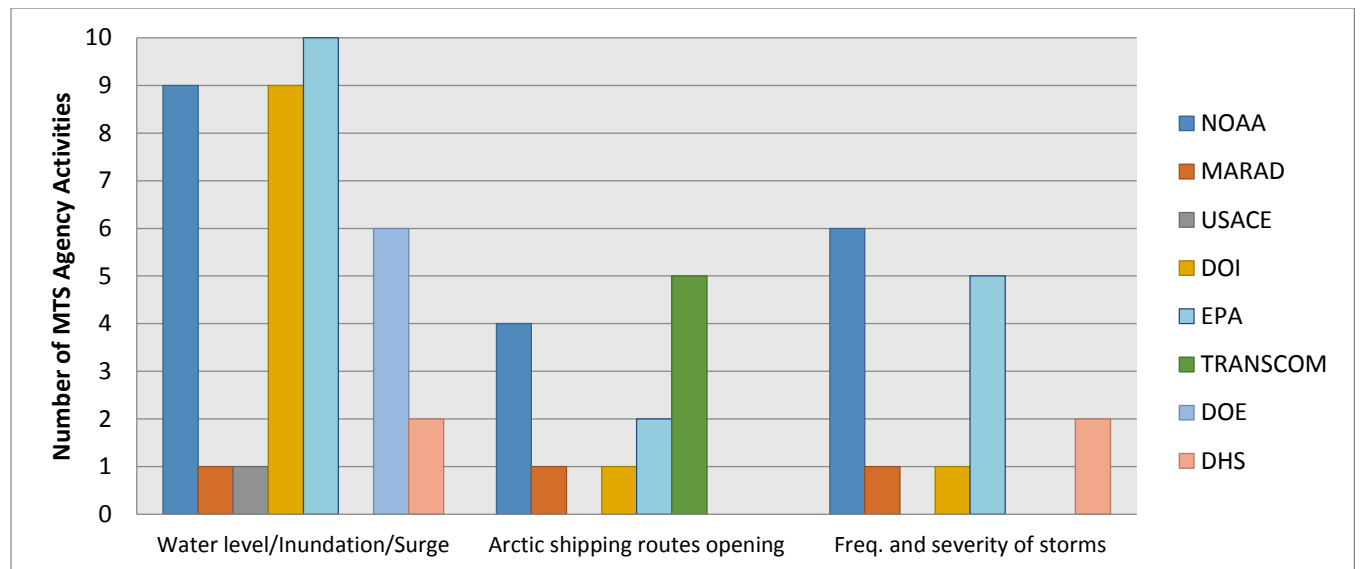


Figure A.3 Environmental Factors: Operations

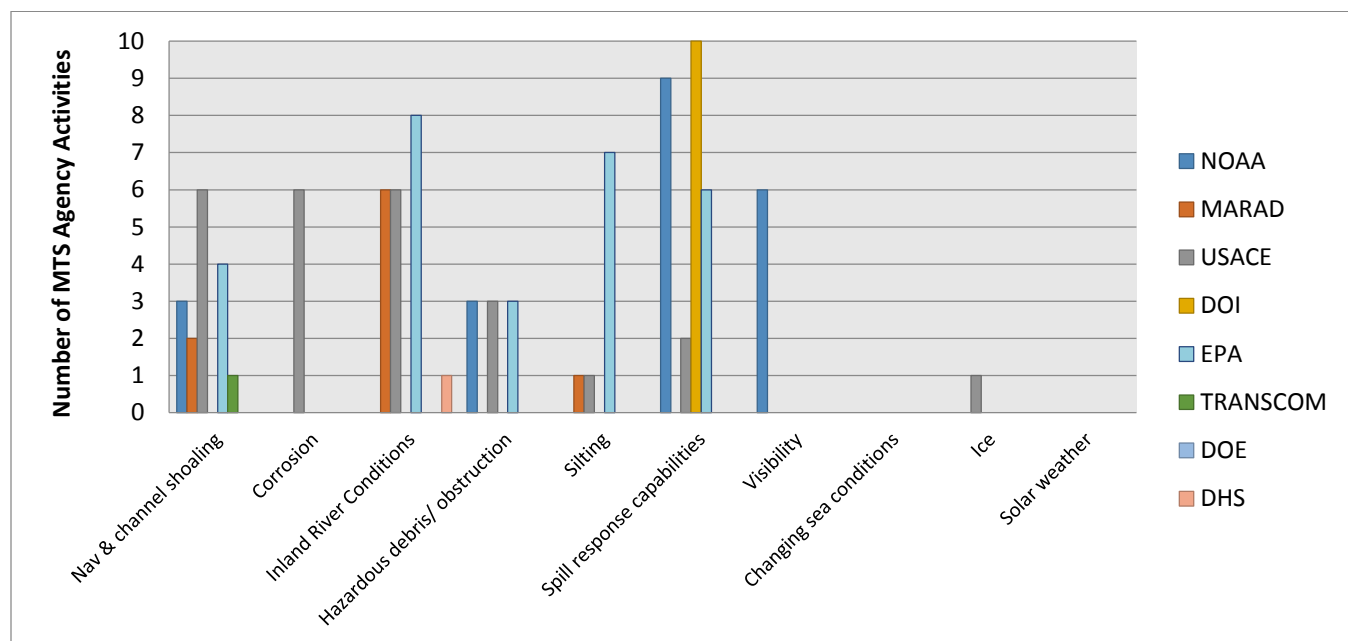
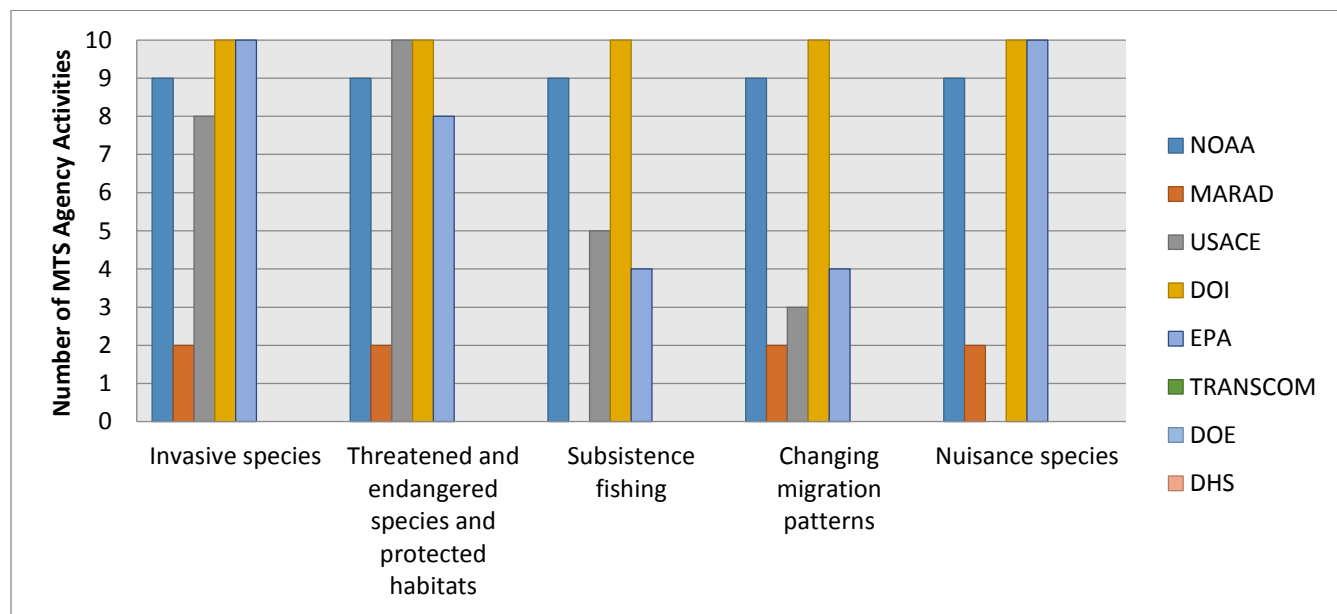


Figure A.4 Environmental Factors: Species



2. Non-environmental MTS Factors

After analyzing the results for agency activities within the non-environmental category, a total of 598 agency activities were recorded. All agencies who contributed to the matrix were significantly involved in various aspects of non-environmental resilience factors. Overall three factors ended up receiving inputs from six or more agencies and a total number of activities in the upper quartile of all non-environmental factors: Emergency Response Capabilities, Infrastructure Resilience, and Regulatory/ Political/ Budgetary. Competing Demands of Multi-modal Transportation Systems, Larger Vessels, and Hazardous Materials/ Oil Spills followed closely behind with five agencies involved. This category included many resilience factors that received a wide variety of input from different agencies. These factors should be thoroughly considered for future work, but for short-term work within the IAT, Infrastructure Resilience was identified as the top priority because seven agencies were actively involved in 37 activities - the highest number for any individual factor in the category.

Figure A.5 Non-environmental Factors: Logistics/Operations

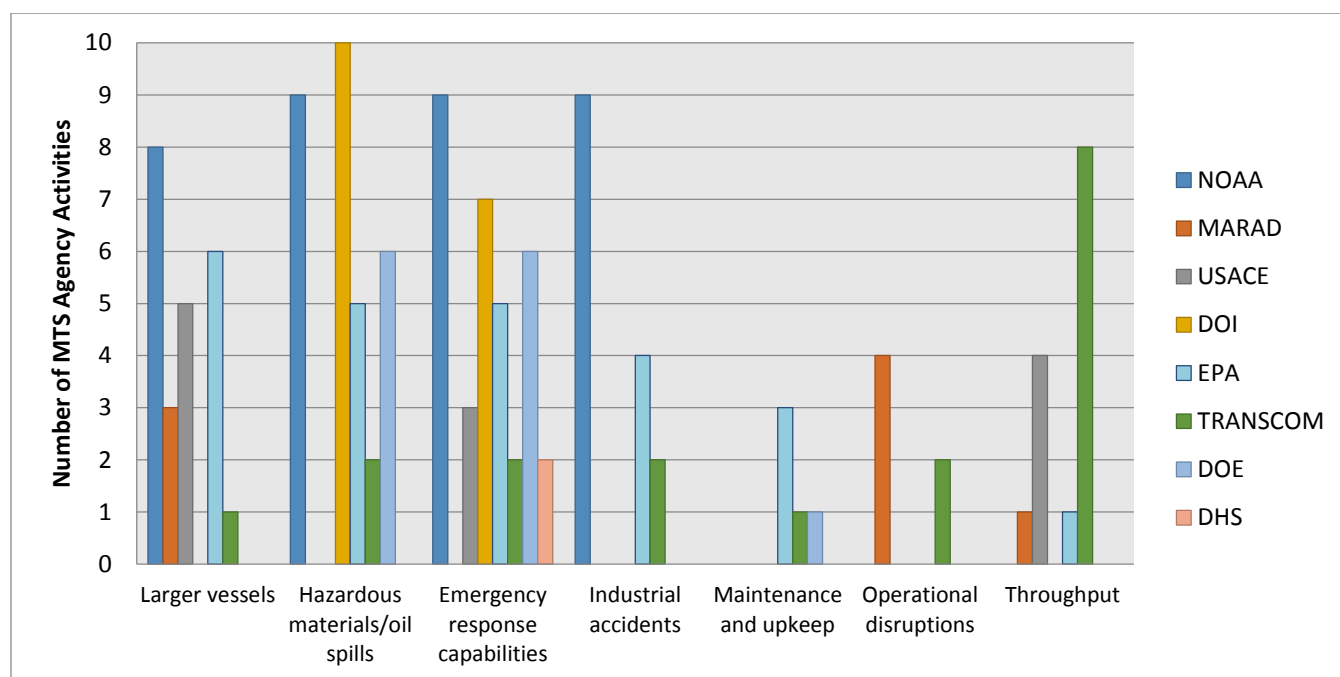


Figure A.6 Non-environmental Factors: Infrastructure

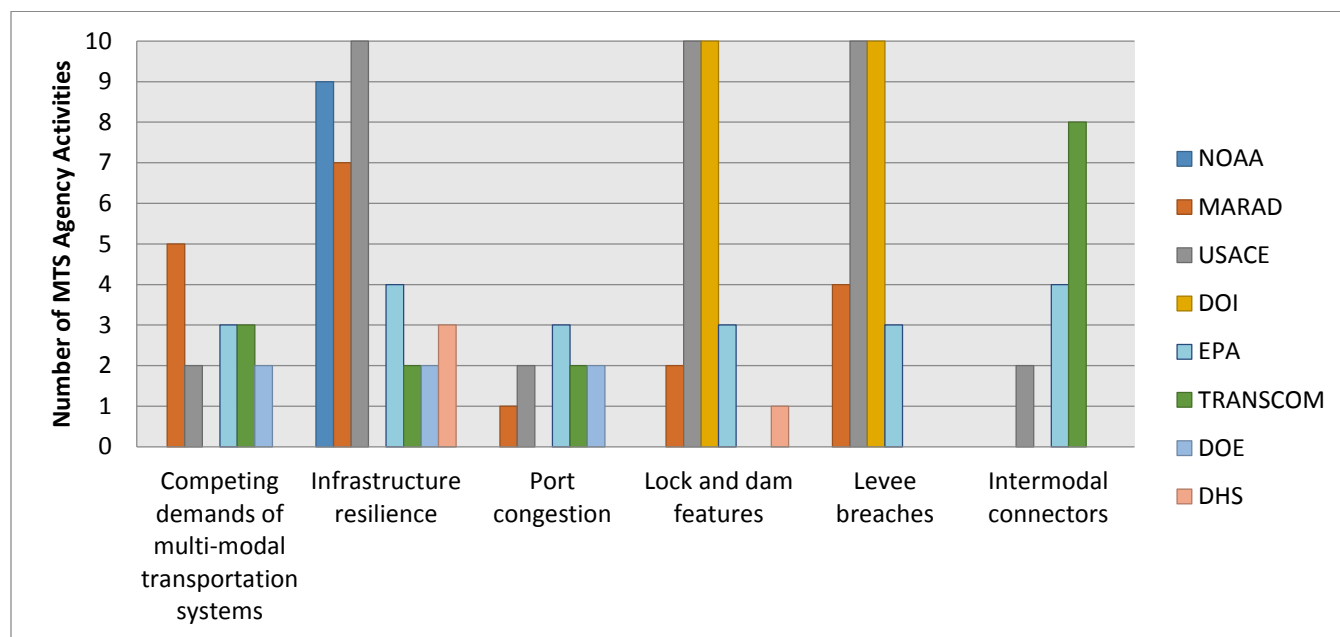


Figure A.7 Non-environmental Factors: Government/Political

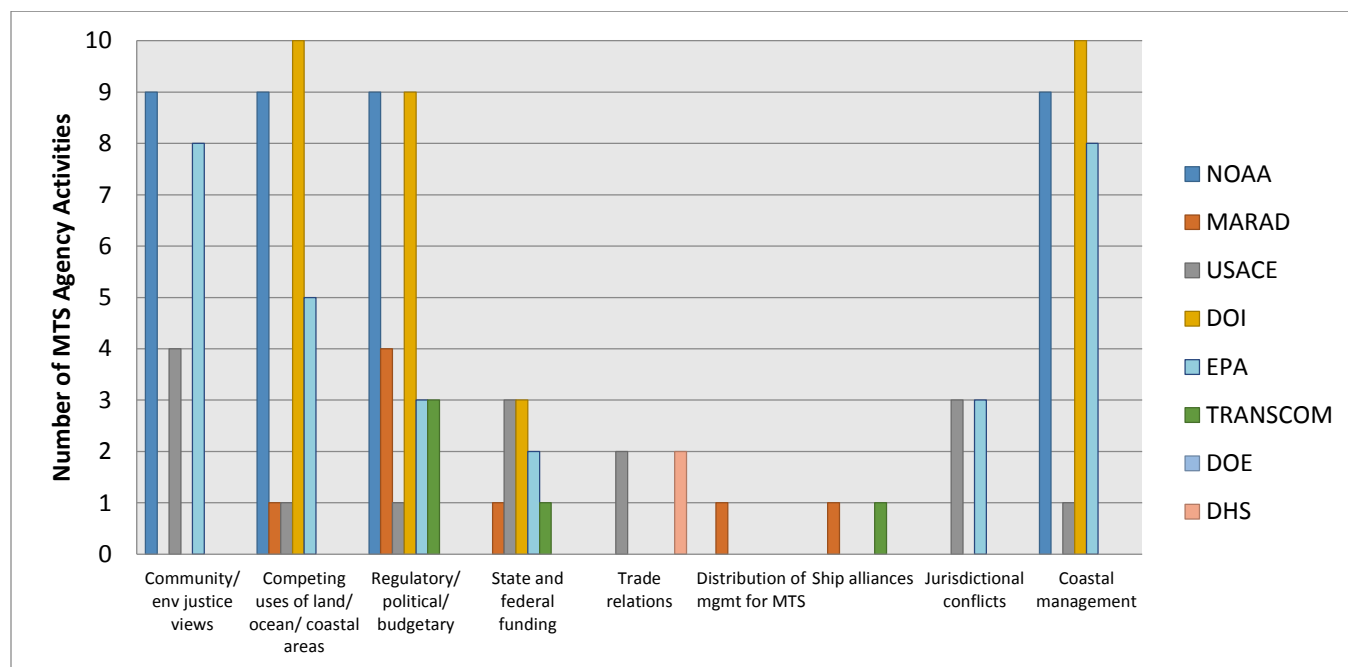


Figure A.9 Non-environmental Factors: Technology

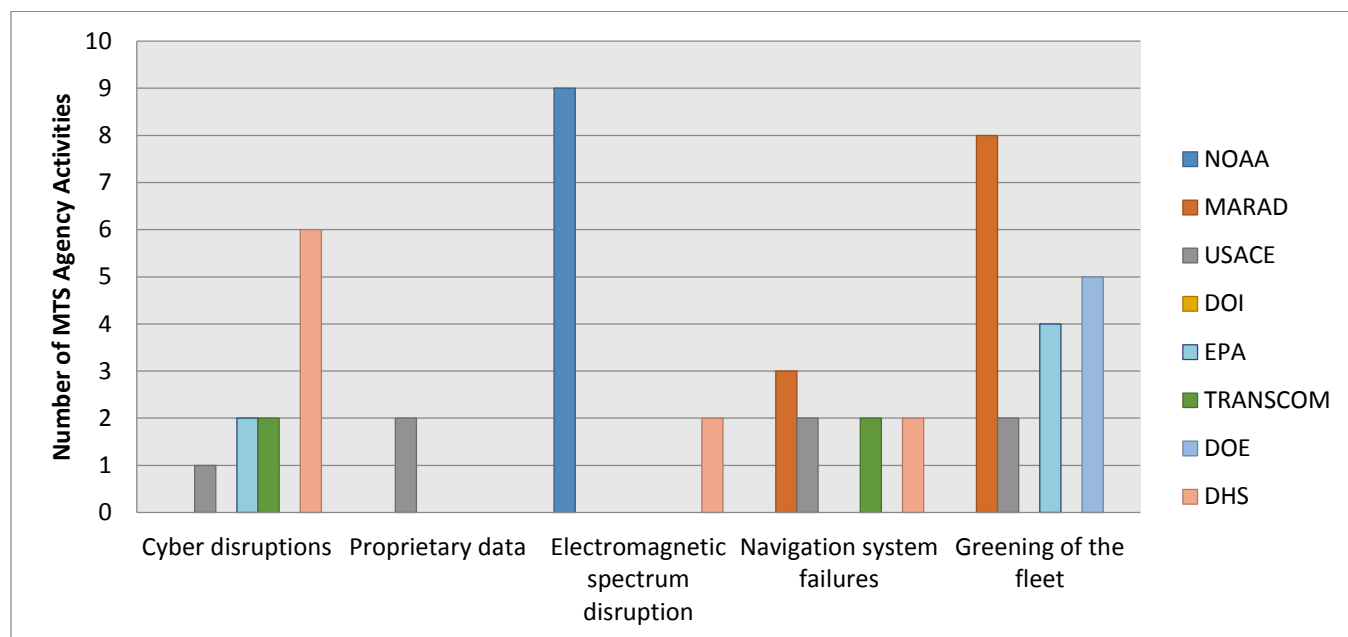


Figure A.10 Non-environmental Factors: Security

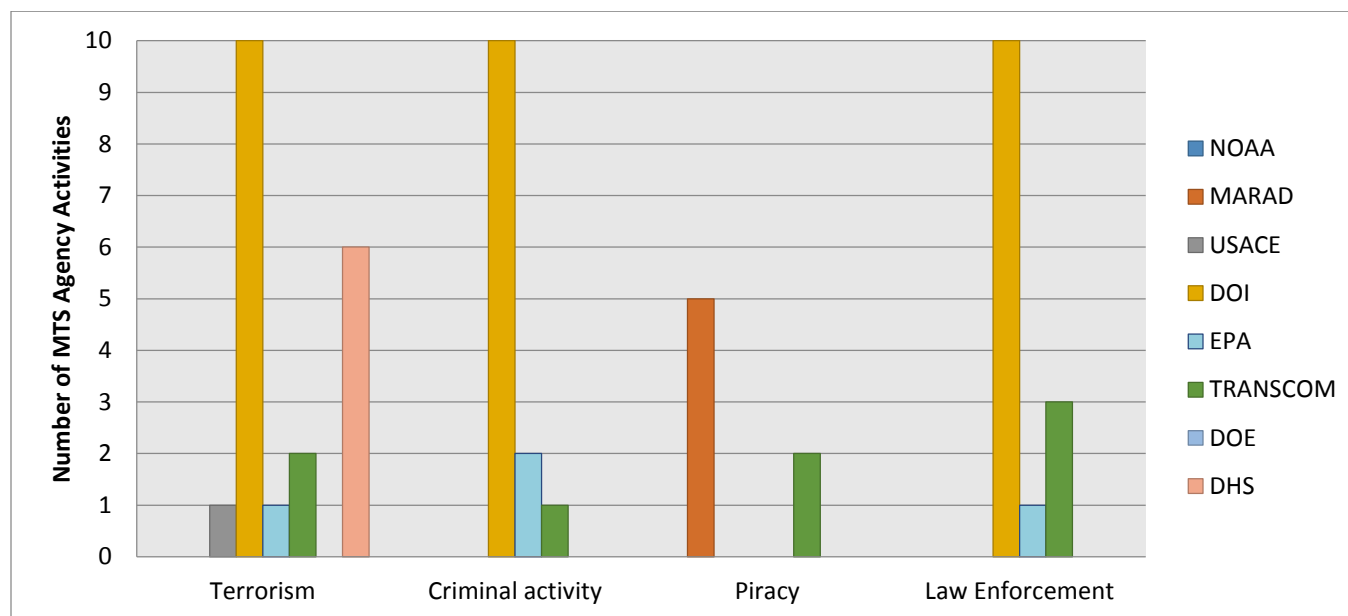
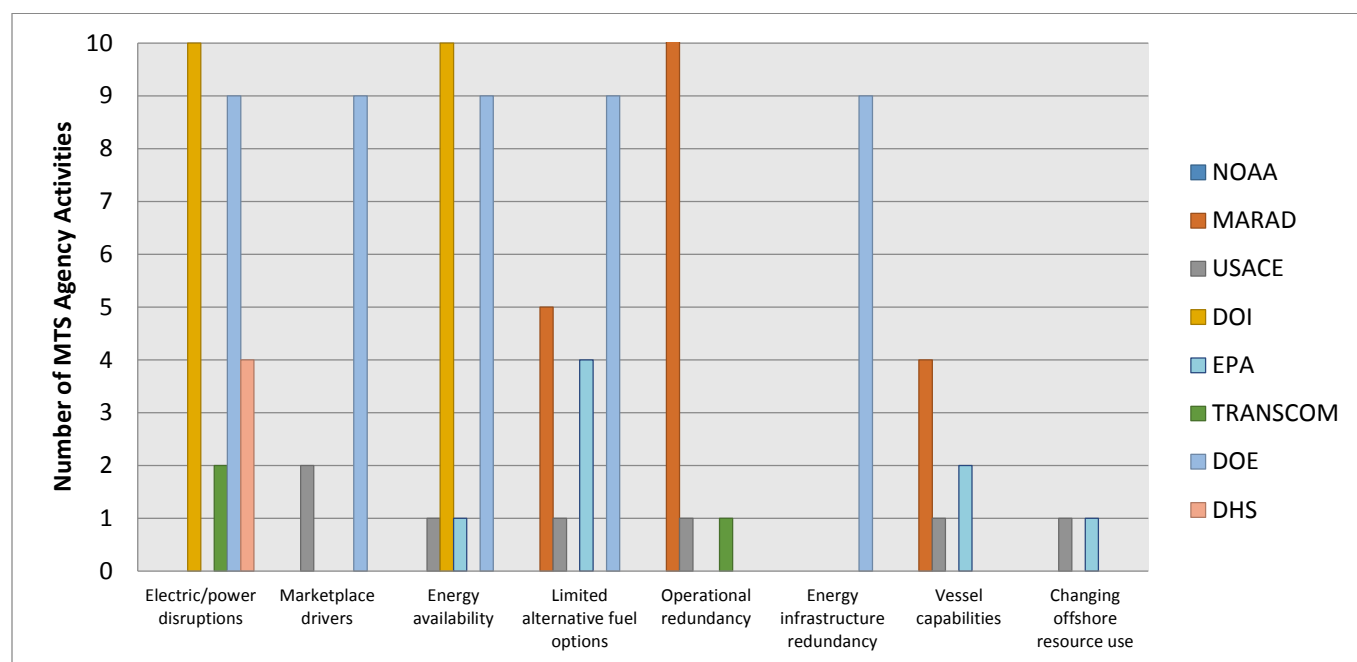


Figure A.11 Non-environmental Factors: Energy



Appendix B. Detailed Agency Actions

The following data are calculated from the responses of the following Resilience IAT agencies: National Oceanic and Atmospheric Administration (NOAA), U.S. Maritime Administration (MARAD), U.S. Army Corps of Engineers (USACE), U.S. Department of the Interior, Bureau of Safety and Environmental Enforcement (DOI/BSEE), U.S. Environmental Protection Agency (EPA), US. Transportation Command (TRANSCOM), U.S. Department of Energy (DOE), and U.S. Department of Homeland Security (DHS).

1. Environmental Resilience Factors

Table B.1 Environmental Factors - Extreme Events								
	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANSCOM	DOE	DHS
Water Level Extremes (Inundation/Surge/Drought)	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 2, 5, 8, 10	2, 8	1, 2, 3, 4, 6, 7, 8, 9, 11	1,2,3,4, 5,6,7,8, 9	1		2,9
Tidal extremes	1, 2, 3, 4, 5, 6, 7, 8, 11	1			1,2,3,4, 5,7,8,9			2,9
Frequency and severity of storms	1, 2, 3, 4, 5, 6, 7, 8, 11	1			4,6,7,8, 9	1		2,9
Extreme precipitation	1, 2, 3, 4, 5, 6, 7, 8, 11	1			4,7,8,9	1		
Extreme heat/thaw	1, 2, 3, 4, 5, 6, 7, 8, 11	1	5		7,8	6		2,9
Extreme cold/ice	1, 2, 3, 4, 5, 6, 7, 8, 11	1	5		7,8	6		
Seismic disruptions	1, 2, 3, 4, 5, 6, 7, 8, 11	1		1, 2, 3, 4, 6, 7, 8, 9, 11	6,7,8	1		2,9
Tsunamis	1, 2, 3, 4, 5, 6, 7, 8, 11	1			6,7,8	1, 6		
Tornadoes	1, 2, 3, 4, 5, 6, 7, 8, 11	1			6,8	1		

The Resilience Factors Matrix is a categorized list of resilience factors identified by R-IAT members. The numbers in the matrix correspond to the following actions: **1.** Data and physical monitoring, **2.** Numerical models and studies, **3.** Defined metrics, **4.** Existing tools, **5.** Studies with spatial domain, **6.** Operations, **7.** Programs, **8.** Partnerships, **9.** Outreach activities, **10.** Other, **11.** Policy development

Volcanic activity		1		1, 2, 3, 4, 6, 7, 8, 9, 11	6,7,8	1		
Wildland Fire				1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1,8,9	1		
Waves			1, 2, 4, 7					
Table B.2 Environmental Factors - Climate Change								
	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS- COM	DOE	DHS/IP
Water level/Inundation/ Surge	1, 2, 3, 4, 5, 6, 7, 8, 9	7	1,2,5	1, 2, 3, 4, 6, 7, 8, 9, 11	1,2,3,4, 5,6,7,8, 9,10		1, 2, 4, 5, 9, 11	2,9
Arctic shipping routes opening	1, 2, 3, 4	7			7,8,11	1,2,6,7, 8		
Frequency and severity of storms	1, 2, 3, 4, 5, 6, 7, 8, 9	10			4,6,7,8, 9			2,9

Table B.3 Environmental Factors - Operations								
	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS- COM	DOE	DHS/IP
Navigation and channel shoaling	1, 4, 7	7, 10	1,2, 3, 4, 5, 6, 7, 8, 9, 11		6,7,8,11	5		
Corrosion			1, 2, 3, 4, 6, 8, 9					
Inland waterways/river conditions		2, 3, 7, 8, 9, 10, 11	1, 2, 3, 4, 5, 6, 7, 8, 9, 11		1,2,3,4, 5,7,8,11			2
Hazardous debris/obstruction	1, 4, 7		1, 6, 8		6,7,8			
Silting			6		1,2,3,4, 5,6,8			
Spill response capabilities	1, 2, 3, 4, 5, 6, 7, 8, 9		2, 6	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	2,6,7,8, 9,11			

The Resilience Factors Matrix is a categorized list of resilience factors identified by R-IAT members. The numbers in the matrix correspond to the following actions: **1.** Data and physical monitoring, **2.** Numerical models and studies, **3.** Defined metrics, **4.** Existing tools, **5.** Studies with spatial domain, **6.** Operations, **7.** Programs, **8.** Partnerships, **9.** Outreach activities, **10.** Other, **11.** Policy development

Visibility	1, 2, 3, 4, 5, 6, 7, 8, 9							
General weather and winds (changing sea conditions)	1, 2, 3, 4, 5, 6, 7, 8, 10							
Ice	1, 2, 3, 4, 5, 6, 7, 8, 11		6					
Solar weather	1, 2, 3, 4, 5, 6, 7, 8, 11							

Table B.4 Environmental Factors - Species

	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS- COM	DOE	DHS/IP
Invasive species	1, 2, 3, 4, 5, 6, 7, 8, 9	2, 10	1, 3, 4, 5, 6, 7, 8, 9	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1,2,3,4,5, 7,8,9,11			
Threatened and endangered species and protected habitats	1, 2, 3, 4, 5, 6, 7, 8, 10	2, 10	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1,2,3,4,5, 7,8,11			
Subsistence fishing	1, 2, 3, 4, 5, 6, 7, 8, 11		6, 7, 8, 9, 11	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	7,8,9,11			
Changing migration patterns	1, 2, 3, 4, 5, 6, 7, 8, 11	2, 10	5, 6, 8	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	5,6,7,8			
Nuisance species	1, 2, 3, 4, 5, 6, 7, 8, 11	2, 10		1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1,2,3,4,5, 6,7,8,11			

Table B.5 Environmental Factors - Other

	NOAA	MARA D	USACE	DOI/BSEE	EPA	TRANS- COM	DOE	DHS/IP
Coastal and riparian erosion	1, 2, 3, 4	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 11		4,6,7,8,9, 11			

The Resilience Factors Matrix is a categorized list of resilience factors identified by R-IAT members. The numbers in the matrix correspond to the following actions: **1.** Data and physical monitoring, **2.** Numerical models and studies, **3.** Defined metrics, **4.** Existing tools, **5.** Studies with spatial domain, **6.** Operations, **7.** Programs, **8.** Partnerships, **9.** Outreach activities, **10.** Other, **11.** Policy development

2. Non-Environmental Resilience Factors Agency Input**Table B.6 Non-Environmental Factors – Logistics/Operations**

	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS-COM	DOE	DHS/IP
Larger vessels	1, 2, 3, 4, 5, 6, 7, 8, 9	7,9,11	1,2, 3, 5, 6		4, 8,9, 10, 11	7		
Hazardous materials/oil spills	1, 2, 3, 4, 5, 6, 7, 8, 10			1, 2, 3, 4, 5, 6, 7, 8, 9, 11	4,6,8, 9, 11	1,6	1, 2, 4, 8, 9, 11	
Emergency response capabilities	1, 2, 3, 4, 5, 6, 7, 8, 10		6, 7, 8	3, 4, 6, 7, 8, 9, 11	1, 6, 7, 8, 11	1,8	1, 2, 4, 5, 9, 11	8,9
Industrial accidents	1, 2, 3, 4, 5, 6, 7, 8, 11				4, 6, 8, 11	1,6		
Maintenance and upkeep			1,2,3,4, 5,6,7,8, 9, 11		4, 7, 9	1	11	
Operational disruptions		7,8,9,11				1, 6		
Throughput		7	1,2,3,4		10	1, 2, 3, 4, 5, 6, 7, 8		

Table B.7 Non-Environmental Factors – Infrastructure

	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS-COM	DOE	DHS/IP
Competing demands (for physical space) of multi-modal transportation systems		1, 7, 8, 9,10	8, 11		6, 7, 8	5, 6, 8	9, 11	
Aging infrastructure	1, 2, 3, 4, 5, 6, 7, 8, 9	1, 5, 7, 8, 9, 10, 11	1, 2, 3, 4, 5, 6, 7, 8, 9, 11		4, 6, 7, 9	1, 5	9, 11	2,7,9
Port congestion		10	1, 2		6, 7, 8	1, 6	9, 11	
Lock and dam features		1, 10	1, 2, 3, 4, 5, 6,	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	6, 10, 11			2

The Resilience Factors Matrix is a categorized list of resilience factors identified by R-IAT members. The numbers in the matrix correspond to the following actions: **1.** Data and physical monitoring, **2.** Numerical models and studies, **3.** Defined metrics, **4.** Existing tools, **5.** Studies with spatial domain, **6.** Operations, **7.** Programs, **8.** Partnerships, **9.** Outreach activities, **10.** Other, **11.** Policy development

			7, 8, 9, 11					
Levee breaches		1, 6, 7, 8	1,2,3,4, 5,6,7,8, 9, 11	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	6, 10, 11			
Intermodal connectors (i.e. supporting road/rail infrastructure)			1, 2		6, 8, 10, 11	1, 2, 3, 4, 5, 6, 7, 8		

Table B.8 Non-Environmental Factors – Government/Political

	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS-COM	DOE	DHS/IP
Community/Environmental justice views	1, 2, 3, 4, 5, 6, 7, 8, 9		7, 8, 9, 11		1,4,5,6, 7,8,9,11		9, 11	
Competing uses of land/ocean/coastal areas	1, 2, 3, 4, 5, 6, 7, 8, 10	8	11	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	4,7,8,9, 11		9, 11	
Regulatory/political/budgetary	1, 2, 3, 4, 5, 6, 7, 8, 11	7, 8, 9, 10	6	1, 2, 3, 4, 5, 6, 7, 8, 11	6, 7, 11	1, 7, 8	9, 11	
State and federal funding		7	8, 9, 11	8, 9, 11	7,8	7		
Trade relations			8, 9					8,9
Distribution of management for MTS		X						
Ship alliances		X				7		
Jurisdictional conflicts			1,8,11		6,7,11			
Coastal management	1, 2, 3, 4, 5, 6, 7, 8, 9		6	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1,2,4,6, 7,8,9,11			

The Resilience Factors Matrix is a categorized list of resilience factors identified by R-IAT members. The numbers in the matrix correspond to the following actions: **1.** Data and physical monitoring, **2.** Numerical models and studies, **3.** Defined metrics, **4.** Existing tools, **5.** Studies with spatial domain, **6.** Operations, **7.** Programs, **8.** Partnerships, **9.** Outreach activities, **10.** Other, **11.** Policy development

Table B.9 Non-Environmental Factors – Personnel

	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS-COM	DOE	DHS/IP
Labor challenges								

Table B.10 Non-Environmental Factors – Technology

	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS-COM	DOE	DHS/IP
Cyber disruptions			5		8, 11	1, 8		2,4,6,7,9,11
Proprietary data			6, 8					
Electromagnetic spectrum disruption	1, 2, 3, 4, 5, 6, 7, 8, 9							7,8
Navigation system failures		8, 9, 10	1, 8			1, 6		8,9
Greening of the fleet		1, 2, 3, 7, 8, 9, 10, 11	5, 6		7, 8, 9, 11		1, 2, 4, 8, 9	

Table B.11 Non-Environmental Factors – Security

	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS-COM	DOE	DHS/IP
Terrorism			8	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	8	1, 6		1,2,7,8,9,11
Criminal activity				1, 2, 3, 5, 6, 7, 8, 9, 11	7, 8	1		
Piracy		7, 8, 9, 10, 11				1, 6		
Law Enforcement				1, 2, 3, 4, 5, 6, 7, 8, 9, 11	7	5, 8, 9		

The Resilience Factors Matrix is a categorized list of resilience factors identified by R-IAT members. The numbers in the matrix correspond to the following actions: **1.** Data and physical monitoring, **2.** Numerical models and studies, **3.** Defined metrics, **4.** Existing tools, **5.** Studies with spatial domain, **6.** Operations, **7.** Programs, **8.** Partnerships, **9.** Outreach activities, **10.** Other, **11.** Policy development

Table B.12 Non-Environmental Factors – Energy								
	NOAA	MARAD	USACE	DOI/BSEE	EPA	TRANS-COM	DOE	DHS/IP
Electric/power disruptions				1, 2, 3, 4, 5, 6, 7, 8, 9, 11		1, 6	1, 2, 4, 5, 6, 7, 9, 10, 11	1,2,8,9
Marketplace drivers			6, 8				1, 2, 4, 5, 6, 7, 9, 10, 11	
Energy availability			6	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	6		1, 2, 4, 5, 6, 7, 9, 10, 11	
Limited alternative fuel options		5, 8, 9, 10, 11	6		6, 7, 8, 10		1, 2, 4, 5, 6, 7, 9, 10, 11	
Operational redundancy		1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	6			5		
Energy infrastructure redundancy							1, 2, 4, 5, 6, 7, 9, 10, 11	
Vessel capabilities		2, 7, 10, 11	6		7, 10			
Changing offshore resource use			8		7			

The Resilience Factors Matrix is a categorized list of resilience factors identified by R-IAT members. The numbers in the matrix correspond to the following actions: **1.** Data and physical monitoring, **2.** Numerical models and studies, **3.** Defined metrics, **4.** Existing tools, **5.** Studies with spatial domain, **6.** Operations, **7.** Programs, **8.** Partnerships, **9.** Outreach activities, **10.** Other, **11.** Policy development