MARITIME SECURITY CENTER
A DEPARTMENT OF HOMELAND SECURITY CENTER OF EXCELLENCE

The Maritime Security Center (MSC)

at Stevens Institute of Technology

Hoboken, NJ

Annual Report

Year 2

July 1, 2015 through June 30, 2016

Submitted on August 26, 2016

APPROVED November 2, 2016

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1. Background

The Maritime Security Center (MSC), a Department of Homeland Security (DHS) Science and Technology (S&T) National Center of Excellence (COE) was established in 2014 as a result of a competition conducted by DHS's Office of University Programs (OUP). MSC is led by Stevens Institute of Technology and this report is based on activities that were conducted by the MSC at Stevens under the Cooperative Agreement during Year 2 (July 1, 2015 through June 30, 2016).

MSC is composed of a consortium of internationally recognized research universities, including Stevens, MIT, the University of Miami, the University of Puerto Rico, Louisiana State University, Florida Atlantic University, and Elizabeth City State University. The contributions of each partner institution during the reporting period are provided with the corresponding projects in this report.

MSC's mission is to develop both fundamental and applied research to support DHS's and other agencies' maritime security mission goals, including improved detection and interdiction capabilities, enhanced capacity to respond to catastrophic events, and a more secure and efficient Marine Transportation System (MTS). MSC has been focusing on interdisciplinary research, education, and technology transition in maritime security, maritime domain awareness, and extreme and remote maritime environment issues. Our goal is to develop and transition research and technology solutions and educational programs to DHS maritime stakeholders, such as the US Coast Guard, Customs and Border Protection, and other related agencies and to improve capabilities and capacities for preventing and responding to events in the maritime domain. The next section describes the research projects.

2. Research Projects

This section discusses the Satellite Surveillance and Port Resiliency research projects. These projects were in the work plan that was approved in June 2015.

2.1. Satellite Surveillance

2.1.1. Introduction

Open ocean satellite-based surveillance is a key capability in the development of Maritime Domain Awareness (MDA), particularly with respect to ship detection, classification and identification. While large vessels are required to carry Automated Identification System (AIS) transponders, smaller vessels, in particular, go-fast, semi-submersibles and other small boats do not transmit a similar message providing basic information of ownership, ship characteristics, position, speed and course, and destination. These vessels are often used as a means to transport illegal drugs and contraband as well as smuggling and trafficking of humans and pose a severe threat to our national security. They operate in the coastal domain but outside the range of terrestrial radar stations and move at low light conditions to elude detections by law enforcement ships and aircrafts. However, satellite synthetic aperture radars (SARs) are sensitive to roughness modulations of the ocean surface and motions of fast moving targets. SARs have demonstrated to be able to readily detect vessels of medium to large lengths. New satellite systems have improved imaging modes and spatial resolutions to allow detections of even smaller boats and non-emitting targets. New algorithms to detect boat wakes can now be used to detect the presence of small, non-emitting boats.

2.1.2. Project Objectives

The purpose of this phase of the project (Phase II) is to build on the Phase I work where satellite data and products were tested for integration into the Air and Marine Operations Surveillance System (AMOSS), operating at the Air & Marine Operations Center (AMOC) utilizing specific data formats. The Phase I research included testing of a delivery path that provided timely and actionable information to the AMOC.

Phase II work will demonstrate the ability of the Center for Southeastern Tropical Advanced Remote Sensing (CSTARS) facility at the University of Miami to provide open ocean satellite-based surveillance information to the Air and Marine Operations Center in Riverside, CA. In particular, CSTARS will demonstrate the ability to receive tasking from the AMOC to detect vessels and provide relevant and timely data to improve Maritime Domain Awareness and enable the tactical operations of DHS Components.

The Phase II Workplan was approved on 30 March 2016 and work began on 5 April 2016. This summary reports on the work that was accomplished since the start of the project to the end of the Project Year.

Table 1 lists the Critical Operations needed to be achieved in sequence to realize the ultimate goal of Phase II – i.e., to provide open ocean satellite-based surveillance information of detected vessels to the Air and Marine Operations Center and provide relevant and timely data to improve Maritime Domain Awareness and enable the tactical operations of DHS Components.

Weekly teleconferencing involving AMOC, DHS and CSTARS personnel were conducted to review current progress and discuss issues and plan for future goals.

2.1.3. Research Milestones Met

Measures of effectiveness (MOE) that have quantitative and/or qualitative evaluation criteria are rated “Pass” or “Fail.” Those areas that do not have evaluation criteria, but where information is needed for the decision-maker are reported using a narrative format. Aggregation of the results is used to determine how well each MOE is achieved, and in-turn, the MOEs is used to resolve the Critical Operational Issues (COIs). The test team (i.e., AMOC) will use all results, combined with test team operational experience and mission expertise, to answer each COI.

The objectives chosen for this experiment should determine the law-enforcement operational utility of CSTARS to contribute to the maritime wide area surveillance requirements of DHS and AMOC. This experiment should also determine if CSTARS can reliably detect “dark targets”.

This Phase II exploratory effort would perform the following Critical Operations (CO) listed below.

Table 1: Critical Operation for Phase II

Critical Operations (CO)	**Milestone: Phase II**	**Performance Metrics**	**Status**
CO-1	CSTARS will establish connectivity with AMOC Operations and display pertinent track data in the AMOSS. This connectivity will be tested using archived test data for cost savings purposes. AMOC will assist with the connectivity as needed.	Establish different connectivity links (open & secure) to evaluate reliability and robustness. **Testing parameter will be data rate and transmission time of various file sizes at different times of day.**	**VPN connectivity established (June 2016). Additional testing of different VPN configurations currently ongoing.**
CO-2	CSTARS will transmit satellite test data to display in AMOSS, as well as Satellite Automatic Identification System (S-AIS) data that shows tactical locations of all vessels in the immediate area of the target vessel.	Perform data transmission tests with S-AIS data to evaluate reliability and robustness. **Testing parameter will be data rate and transmission time of various file sizes at different times of day.**	**Test data of satellite images and S-AIS messages transferred to AMOSS for format verification (May 2016).**

CO-3	CSTARS test data will be formatted for display in AMOSS and will show detected target details such as: a. Synthetic Aperture Radar (SAR) target b. target position c. target course d. target speed e. Provide some parameters on Probability of Detection (PD) and Probability of False Positive (PFP) for various classes of maritime vessels.	Test data will be reproduced at data formats consistent for display in AMOSS. This testing will involve the detection and location of targets in exploitable data sets for display in AMOSS. The detection reports received by AMOC will include PD and PFP for various vessel classes. **Detection in a) will be compared to S-AIS based data in b) to c). Test parameter e) will be computed from known data sources (e.g., S-AIS and AIS data).**	**Test data of satellite images with the AMOC preferred formatting of detected vessel information transferred to AMOSS for format verification (May 2016).**
CO-4	After completion of CO-1 through CO-3, CSTARS will conduct a live data test with AMOC, delivering CO-1 through CO-3 in near real time.	Establish timelines of the TCPED process. **Testing parameter will be time to deliver actionable and exploitable data products to AMOC in live test.**	**Currently working with AMOC to schedule and complete. Anticipated start date August 2016.**

CO-5	After successful completion of CO-4, CSTARS will conduct 4 follow on tests to demonstrate time latency for real time tasking using SAR and EO imagery as follows: a. pre-arranged between CSTARS and AMOC in ScanSAR Narrow and ScanSAR Wide mode at specific dates and times to demonstrate time latency of tasking and ensure that the data can be displayed in a tactical environment. b. Upon successful completion of the scheduled tests (a), two no-notice tests will be completed using ScanSAR Narrow and ScanSAR Wide mode during normal working hours Monday-Friday between the hours of 0900-1700 Eastern Time. c. Focus areas of tests will be the East Pacific AOR out to 200 NM, the Florida Straits, or the Gulf of Mexico. Specific locations to be imaged will be identified by the AMOC.	Establish timelines of the TCPED process in a tactical actionable timeframe for different satellite imagery data (i.e., modes) under different conditions and settings as well as locations. **Testing parameter will be time latency to deliver actionable and exploitable data products to AMOC and data product quality for display to AMOSS in tactical environment.**	**Currently working with AMOC to schedule and complete.**

Expected outcome of ***Phase II: Operational TCPED Capabilities*** to provide CSTARS' multi-sensor satellite data and products to AMOSS. The completion of the Phase II testing of satellite data and products for enhancing the operational picture of the maritime domain will include an E2E "live" test in near-real time for a simulated response by AMOC.

Initial discussions focused on data formats suitable for ingestion into the AMOSS system. AMOSS decided upon raw satellite AIS (S-AIS) NMEA format. For radar imagery information, the OTH-GOLD format with image chips from detected vessels. CSTARS provided samples of both formats for ingestion into the AMOSS system.

The electronic transfer of data was the next subject addressed. CSTARS provided AMOSS a network connectivity capability as per the AMOC's request. The electronic transfer method selected was secure FTP (sFTP) over a Virtual Private Network (VPN) with CSTARS pushing data across the network and AMOC automating a system to transfer data to their servers. AMOSS established a VPN connection and CSTARS tested the connection. First tests were with manual data transfers, then with automated transfers via a python script. A small data set of S-AIS and OTH-GOLD data were repeatedly transferred across the network for 15 days. 1758 files (about 38 GBs of data) were transferred at an average transfer speed of 1100 kbits/sec. This was deemed as acceptable by the AMOC.

Figure 1 shows the data transfer time as a function of time over a two-week period. Figure 2 shows the average transfer rate as a function of time of day. This figure shows that for most part of the day, the average transfer rates are around 1100 kbits/sec. The testing of data transfer of large files started in Year 2 and is expected to be finished during the last week of July.

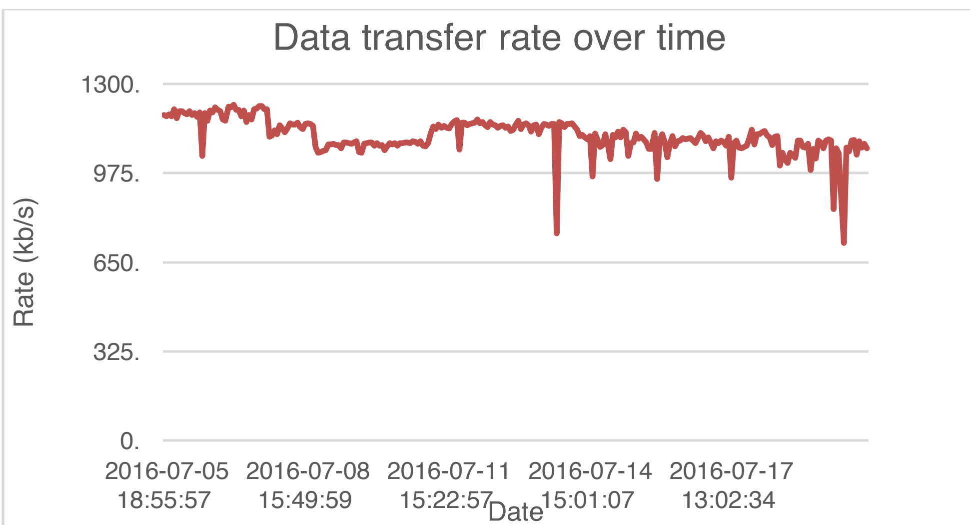

Figure 1: Data transfer rate between CSTARS and AMOC using VPN connectivity during a 15 day testing period.

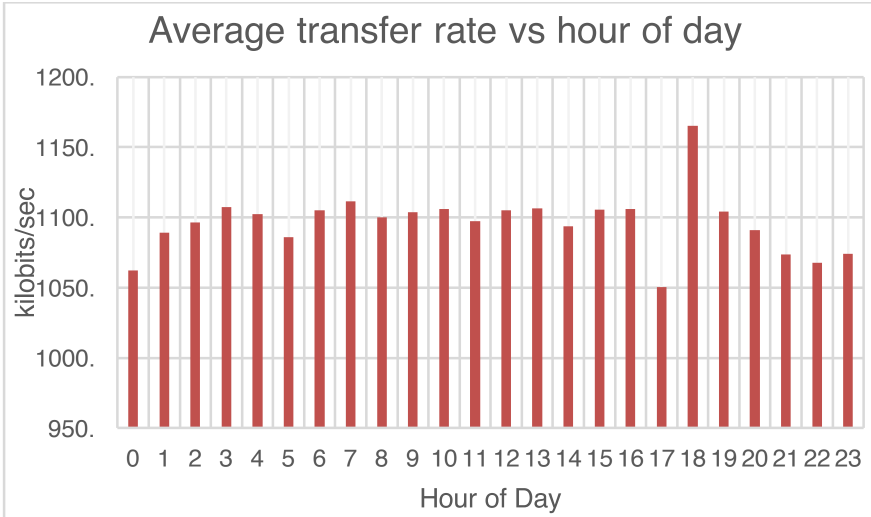

Figure 2: Average data transfer rate as a function of time of day.

The costs for CO-4 and CO-5 were discussed with key stakeholders from DHS and will be included in the next annual report as the work for Phase II is still ongoing. In addition to the Milestones, the following activities took place:

a. MSC Satellite Maritime Domain Awareness Status Meeting, at CSTARS in Miami, FL on 15 September 2015

The purpose of this meeting was to discuss CSTARS progress and milestones with all key players and stakeholders from University of Miami, MSC, DHS, and AMOC. In addition, project issues as well as a plan on how to move forward and implement CSTARS capabilities at AMOC were discussed. During the meeting, information was presented that did not adhere to the guidelines of the Center's Cooperative Agreement for sensitive information. This action was corrected by invoking the Center's information protection plan. Also, at the meeting it was discovered that some milestones were disrupted. This resulted in restricting the project funding until the PI worked with DHS BMD and the AMOC principals to develop a revised work plan that was acceptable to all parties.

b. Phase II discussion, at DHS in Washington, DC on 10 March 2016

A meeting was held between the research PI and stakeholders from DHS, including representatives from DHS S&T's Borders and Maritime Division and the AMOC. The purpose of this meeting was to finalize Phase II Workplan with AMOC and DHS personnel to move forward and implement CSTARS capabilities at the AMOC.

c. Weekly Telcon to discuss progress and future work commencing on 5 April 2016

Telcons that involve CSTARS, AMOC and DHS personnel were held on a weekly basis to focus specifically on COs progress and to mitigate any potential problems with future COs.

Discussions involved the exploration of DOE's ESnet connectivity as an option; generation of a logical connection chart between CSTARS and AMOC VPN endpoints; and processes for satellite radar data integration in the coastal and maritime domain, in support of the Air and Marine Operations Center (AMOC).

2.2. Port Resiliency

2.2.1. Introduction

Major disruptions at a port may result from external threats such as storms, terrorism, labor disputes, and oil or hazardous material spill as well as multiple catastrophic events. The extent of the disruption and damage to a port, and the duration of the disruption depend on the severity of the threat, the degree to which the port is vulnerable to it, and the decisions that are made in responding to the disruption. Resiliency of a port is defined in terms of the severity of the impact of the disruption to a performance measure such as port capacity as well as in terms of the duration of the impact on the performance measure. Hurricane Sandy demonstrated the impact of a storm surge on the Port of New York and New Jersey, highlighting the Port's resiliency and vulnerabilities. Resiliency of US ports is critical to maintaining the flow of maritime commerce and the movement of vital products through America's seaports, in turn being critical to national security and defense readiness perspective (Sturgis et al., 2014). A port resiliency assessment and planning tool is being developed based on simulation and modeling tools available in the transportation planning. The tool is aimed as an aid to port planners, operators, port recovery officers and the USCG in effective port preparedness for potential disruptions and decision-making and communication in recovering from the disruption. The project is led by Florida Atlantic University and collaborators include LSU and UNO.

2.2.1. Project Objective

The principal objective is to develop a cost-effective port resiliency assessment and planning tool that can be adapted, through a choice of interchangeable event modules, to assess and plan for evolving threats and hazards to a port and its waterside and landside distribution capacity, in support of avoidance and mitigation of damage and capacity reduction, and aiding rapid recovery from disruptions. The aim is to develop an integrated tool based on a systems approach to port distribution capacity, port operations, risk management, and policy and jurisdiction considerations and involving simulation and modeling. Other objectives include: 1) Development of a simulation model for selective intermodal facilities that is going to cover operation and logistics, 2) Study and analysis of optimization problems related to resilience that are commonly encountered in intermodal/port facilities to incorporate various stochastic elements such as uncertainty for the terminal's performance measures in order to evaluate the performance of optimization algorithms under different scenarios, and 3) Promotion of graduate and undergraduate education in transportation and marine engineering.

2.2.1. Research Milestones Met

Research Milestones - Status

Milestone	**Performance Metrics**	**Status /Discussion**
I. Problem Definition		
1. Attended and participated in organized workshops and additional meetings with USCG and with MSC on port resiliency	Adequate information is available to develop definition of the port system in simulations	**Completed.** Visited USCG RDC, Port of Palm Beach and Port Everglades. Visited by Sector Miami Held follow up conference call and email discussions with USCG RDC and Sector Miami personnel. Port system defined to initiate simulations; Scope of project established. Section 1 below provides additional information.
2. Port system definition complete	Basic simulations can be performed using the defined port system	
3. Preliminary scope of the tool established	Positive feedback from USCG on the fidelity of the proposed tool and its limitations. The original metric was conditional – based on results of Task 1. The scope was established with feedback from RDC.	
4. Case studies for port activities established; modeling and coding simulation in Aimsun initiated	Modeling of simple port processes can be demonstrated through simulation	**Completed.** Case studies for Port Everglades, Port of New Orleans and Port of LA established. Simulation models initiated.

Milestone	Performance Metrics	Status /Discussion
5. Port vulnerabilities identified	Acceptable results (to be defined as part of Task 1) of survey of stakeholders	**In progress.** Some of the vulnerabilities at Port Everglades identified with port personnel. Awaiting access to HSIN-CI reports and data from personnel at other ports to fully identify port vulnerabilities. Access has not been granted. Additional requests will be made.
6. Required data on impact of previous hazards on ports identified and gathered	Results of survey of stakeholders to assess if all available data have been gathered; adequate information available to assess identification of several external disrupters	**In Progress.** See M5
7. External disruptors identified; Port rules, policies and decision-making processes established	Acceptable results (to be defined as part of Task 1) of survey of stakeholders;	**In Progress.** Scope of project fixed to consider port resiliency to external disruptor scenarios: 1) storm surge related flooding at Port Everglades, 2) Oil spill at Port of New Orleans, and 3) Labor dispute/ strike at Port of LA and Long Beach. More data on port rules, decision-making processes being gathered

Milestone	Performance Metrics	Status /Discussion
8. Requirements for the proposed tool defined; developments of the Port Resiliency Indices	Acceptable results (to be defined as part of Task 1) of survey of stakeholders; Required performance metrics for the tool and thresholds available to initiate simulation of test scenarios	**In Progress.** Preparation of comprehensive IRB approved stakeholder surveys in progress. A stakeholder workshop is planned for October 2016.
II. Development of Concepts for the New Tool **III. Development of the New Tool**		To be completed July 1, 2016 – June 30, 2017

2.2.2. Accomplishments

Background information, including previous work in the area has been examined. Based on available information and stakeholder discussions, the scope of the project has been defined to include three disruptive scenarios: 1) disruption at a port along the east coast due to a major storm, 2) disruption at a port in the Gulf of Mexico due to an accident involving major oil spill, and 3) disruption at a port along the west coast due to a labor strike. Requisite data are currently being sought from Port Everglades, Ports of New Orleans and Houston, and Port of LA/Long Beach as initial considerations in developing the port resiliency assessment and planning tool. Stakeholder survey questions have been prepared and Port Authorities and related stakeholders are being contacted (see Appendix 4). Literature reviews have been conducted to identify existing related tools, identify threats and associated vulnerabilities, as well as various strategies employed to mitigate impact and to recover from disruptions. Development of AIMSUN based simulation case studies of the various types of disruptions, such as storm-related flooding at Port Everglades, and their impacts is underway in order to establish the necessary databases. Case studies form the basis for modeling and simulation, tool verification and stakeholder engagement. The case studies will be made available as part of the tool when complete.

1. Stakeholder Identification and Engagement

A stakeholder list has been identified, which includes representatives of the USCG, key ports, DHS, and others. We are working with Sector Miami to extend this list. The plan is to engage these individuals through email, personal contact, visits, and through a Port Resiliency Workshop which is planned for at FAU for October 2016. Briefs were provided at USCG R&D Center in September 2015, to USCG SECTOR Miami personnel who visited

FAU on May 31, 2016, to Port of Palm Beach in June 2015 and to Port Everglades in June 2016. (The current list of stakeholders is given in Appendix A of this section of the Report).

FAU has been invited by Sector Miami to provide a brief to the AMSC Executive Committee on August 10, 2016. The meeting will give us an opportunity to engage several local and regional stakeholders. The stakeholder engagement and discussions may be summarized as follows:

- Engagement with USCG RDC personnel during a visit to the RDC in September 2015 and subsequent teleconferences was helpful in identifying pertinent stakeholders, and developing strategies in developing the proposed port resiliency tool. RDC welcomed our initiative in reaching out to them and other stakeholders early so that the tool is not developed in isolation, without consideration of stakeholder needs. It was important to target the end user and to identify the prime driver who will be operating the tool. Typical port structure and associated issues were discussed. Each port is unique involving multiple private/public entities, with complex responsibility structures. Port capabilities and limitations, which impact its resiliency, are often dictated by local conditions. For example, at Port Charleston cranes can only reach half way across the channel in view of its width. The needs and demands at ports are constantly evolving. Various port disruption scenarios were discussed, including power outages, terrorist attack, medical evacuation, oil spill and natural hazards such as a hurricane. Hurricane Sandy created backlogs not only at Ports of NY/New Jersey but ripple effects all the way to Houston – everything is interconnected and involves political decisions. It was felt that we needed to consider major ports on a nationwide basis. As a result of these discussions, it was recommended that we focus on three disruptive scenarios that could lead to port closure: 1) a hurricane on the east coast, 2) a major oil spill at a Gulf of Mexico port, and 3) a labor dispute at a port on the west coast. USCG suggested that the proposed tool could serve as a communication tool for pre and post sequence of events – USCG plays an important role in determining when a port needs to close and when it could reopen. Relevant measures for the proposed resiliency tools needed to be defined. It would be useful to think out of the box and develop a systems engineering diagram of a port. Typical survey questions for ports were discussed: What is your business continuity plan? How long can you operate without power? etc. Determining port vulnerabilities may be difficult as ports may withhold information in this regard for various reasons.

- Sector Miami personnel visited FAU in May 2016 and were given an overview of the proposed project. Ensuing discussions provided insights into port security and port recovery procedures following a disruption. We were invited to attend an AMSC executive meeting on August 10, 2016 to meet with and make a presentation to stakeholders associated with several Florida ports.

- A tour of the Port of Palm Beach was conducted in June 2015 where we learned about several aspects of port operations that could affect its resiliency. In June 2016, we met with several personnel at Port Everglades and gave them an overview of the proposed project. We learned about their concerns about potential power outages associated with storm surge related flooding. Port Everglades has agreed to participate in the project and have appointed an individual who will serve as our point of contact.

2. Background and Literature Review

As part of Milestone 3, a literature review was carried out to review previous related efforts. A number of port resiliency tools have been proposed. These include:

a. **Maritime Security Risk Analysis Model** (MSRAM) by USCG was designed to identify and prioritize critical infrastructure, key resources and high consequence scenario's across sectors using a common risk methodology, to measure security risk from terrorism at the local, regional and national levels.. https://www.uscg.mil/proceedings/archive/2007/Vol64_No1_Spr2007.pdf

b. **Port Security Risk and Resource Management System** (PortSec) is a risk assessment and security resource allocation system targeting seaport operations, based on the Ports of Los Angeles and Long Beach. It is targeted at providing support to the Port Security Officer and Port Security Analyst. Consideration is on economic impact of a terrorist attacks at the two ports. http://research.create.usc.edu/cgi/viewcontent.cgi?article=1086&context=project_summaries

c. **Port Mapper** was developed by MIT, in support of identifying domestic US ports that could possibly absorb cargo in the event of a disruption at a port. It provides end-users with the capability to visualize port locations and to conduct real-time and scenario based disruption analysis. http://portmap.mit.edu/

d. **Port Tomorrow Resilience Planning Tool** was developed by was developed by the NOAA Office for Coastal Management along with other NOAA offices and members of the federal interagency Committee on the Marine Transportation System for officials planning for the infrastructure of ports, in support of safety, economic stability, and resilient freight transportation infrastructure. The tool is based on providing checklists, local maps and local case studies to illustrate the concepts. http://webqa.coast.noaa.gov/port/

e. **Port Resilience Atlas** developed by NOAA is a web-based atlas that provides easy access to port-related data and information. These data maps can be used to show the health and condition of the port and surrounding community in terms of investments, modernization, and resilience. It provides information about marine transportation, port community, and coastal hazards for the nation's ports and allows analysis of vessel calls, import and export information, and planning boundaries. https://coast.noaa.gov/digitalcoast/tools/port.html

f. **Virtual Port** is a ArcGIS-based dynamic operational planning tool developed by Port of LA/Long Beach, providing real time status of activities and events throughout the Port. It supplies Port stakeholders with timely data for business resiliency, daily operations, threat and incident response, asset & property management and event documentation.

Virtual Port is a modular platform that consists of numerous independent software applications that create a tool box concept. It has four primary data sources: storage of historical data; collection of dynamic, open-source data; visualization date, pictures, maps, charts, etc.; and built-in process/incident models. Virtual Port is an informational tool for referencing, modeling and processing existing information. http://www.polb.com/news/displaynews.asp?NewsID=1310&TargetID=23

In 2011, President Barack Obama's Presidential Policy Directive (PPD-8) defined resilience as "the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies" (PPD-8, 2011, n.p.). As noted by Kostro & Riba (2014, p. 1), to achieve resilience, efforts need to be put in place throughout the emergency management cycle, which includes the following five targeted mission areas established by the Department of Homeland Security (DHS), namely protection, Prevention, Mitigation, Response, and Recovery

These five mission goals taken together with the definition of resilience provides guidance for how to frame the current model being designed for the Port Resiliency Project. Decision-makers often find themselves torn between spending limited resources among these competing goals especially the goals of prevention and mitigation, which forms the foundation of disaster preparation and emergency management (Comfort, Boin, & Demchak, 2010).

By studying the literature, [1-7]it is clear there is no consistent, quantitative approach to define resiliency among the many fields and disciplines of infrastructure networks. To address this issue, Henry and Ramirez-Marquez (2012) first proposed a fundamentally quantitative approach to estimating resilience that is applicable to various disciplines. They proposed resiliency as a time-dependent function where system deliverables are quantified for the duration encompassing before, during, and after a disruptive event. This approach was also applied to stochastic systems in subsequent work [8] [9].

Resiliency in Maritime Transportation Systems

Concerning resiliency of the MTS, previous studies introduced techniques to reduce vulnerability and increase coping capacity. The vulnerability reduction strategies include the implementation of robustness, redundancy, diversity, modularity, and rapidity into the system network, whereas the scenarios to increase the coping capacity of the system cover resourcefulness, collaboration, preparedness and cognition [10]. Along these lines, MTS resiliency can perhaps best be measured in terms of time, cost, capacity (loss), and environmental impact. By quantifying these measures both before and after a disruptive event, it is possible to measure the full impact of the disruption on serviceability and recovery.

3. Development of Stakeholder Surveys and Resilience Indices

To analyze the role of stakeholders and other factors affecting port resilience, a survey and interview questionnaire has been developed to acquire this information from the three identified ports. The survey questions have been prepared and submitted for IRB approval. However, some of required information has been gathered as discussed in the revised section 1 above. The questionnaire will seek information that specifically identifies how these ports are currently meeting DHS's mission goals, if and where challenges arise, and to identify factors that assist in communication and the coordination of recovery planning with various stakeholders. The survey will be disseminated to port officials who manage port and maritime security operations and to members of the Area Maritime Security Committees that are linked to each of the ports in the study area.

A summary of the categories and sample questions that will be used for the stakeholder surveys are given below.

Stakeholder Surveys	
Categories	**Sample Questions**
Key Questions	1. What disruptive events have occurred at your port? 2. What impact did it have, what decisions were made and what were the major issues?
Preparedness Plans and Strategies	1. What plans do you have in place for responding to disruptions? 2. Do you conduct regular assessments of critical infrastructure for resiliency?
Coordination / Decision Making	1. Who is involved in responding to disruptions? 2. How do you coordinate with external partners and governmental agencies? 3. Do you have mutual aid agreements with neighboring ports? 4. How do you communicate with your customers? 5. What key decisions were made in responding to a previous disruption?
Continuity of Operations	1. What are the most important considerations ? 2. What are the major challenges or obstacles? 3. What key steps would you take to enhance capacity and service?
Big Picture – Post Disruption/Recovery	1. What steps worked best in previous disruption? 2. What were the lessons leaned? 3. What improvements can be made in enhancing recovery?
Resources / Insurance	1. Are adequate contingency resources available for responding to a disruption? 2. What measures do you take for archiving data and critical records?
Port Resilience	1. What are the major challenges or obstacles to improving port resilience?

In addition to the data expected to be collected from the stakeholder surveys, a review of existing plans, policies, and regulations has been initiated to determine port vulnerabilities and adaptive resilience capacities. Further, current plans and policies ranging from the SAFE Port Act of 2006, to Area Maritime Security (AMS) and contingency plans are being reviewed to identify recovery planning components. Data from FEMA, the Department of Transportation, and other sources are also being compiled. In addition decision-making processes related to recovery and building resilience are being identified from plans.

Data collected on the ports through the surveys and the secondary data sources discussed above will be used to develop resilience indices for each port (some data has been obtained through discussions as discussed in Section 1). Sub-indices of resilience in areas such as communications, coordination and collaboration, infrastructure protection, operations and contingency planning, etc. will also be developed. Data on these components will be included in the simulation model and planning tool and will be incorporated into the assessment and planning tool being developed. These indices and the new planning tool will be used to develop a list of best practices and policy recommendations. The following represents part of the overall effort and includes work that has been completed in Year 1 of this project.

4. Scenarios

Three scenarios have been selected based on three ports and three specific disruptions to focus upon in illustrating the Smart Port Resilience Assessment and Planning Tool being developed. The ports and incidents are as follows:

1) Port Everglades: Storm surge and flooding associated with a major storm
2) Port of New Orleans: Oil Spill/Bio-hazard Spill
3) Port of Long Beach: Labor Strike

Each of these Ports and disruptions require a different sets of data and variables that will be incorporated in a simulation model and analysis to arrive at a set of recommendations that will lead to achieving DHS's five targeted mission goals in developing resilient ports.

Some Basic Statistics for 2015 for the three ports are:

	Port Everglades	**Port of New Orleans**	**Port of Long Beach**
Total Port-wide Cargo (Short Tons)	24,001,663	33,576,064	40,388,966
Total General Cargo (Break-bulk and Container; Short Tons)	7,024,093	9,541,260	7,192,069
Number of Cruise Passengers	3,773,386	1,023,700	N/A

5. Case Studies

Several case studies (that correlated with Milestone 12 of the Work Plan), based on available data, are underway in the process of developing the necessary algorithms that will make up the Port Resilience Assessment and Planning Tool. During this period, the research team worked on Tasks 5 through 7 identified in the Work Plan. Five cases of port disruption, in terms of the impacts on waterside and landside capacities, are discussed below: 1) Closure of Galveston Channel due to an oil spill, 2) Closure of Port of New York and New Jersey due to Hurricane Sandy, 3) Simulated partial closure of Port Everglades due to flooding.

Methodology

The overall tool development approach is based on modeling and simulation, taking a systems approach to port distribution capacity, port operations, risk management, and policy and jurisdiction considerations. Risk management of a catastrophic event (Conger, 2011) involves careful assessment of the vulnerability of the port to natural and human-caused catastrophic events; implementation of prevention or risk reduction measures to avoid or mitigate damage; advance preparation for quick and effective response and proactive measures to ensure financing is available to cover the costs of response and recovery. Principal considerations in the approach include:

- *Identification of threats and hazards to port transportation system*
- *Safety, security and resiliency of the port infrastructure*: Requirements for port operations and increase in capacity, weather readiness, exposure and mitigation of threats and hazards, disaster response
- *Safety, security and resiliency of the waterside distribution capacity*: Requirements for sea freight, navigation infrastructure, ship traffic management, maritime surveillance, weather readiness, exposure and mitigation of threats and hazards, disaster response
- *Safety, security and resiliency of the landside distribution capacity*: Requirements for road and rail freight, road and rail infrastructure, Intermodal connections, weather readiness, exposure and mitigation of threats and hazards, disaster response
- *Interagency and stakeholder coordination*: Community resources and societal impact, compliance with policy, jurisdiction and maritime security governance

The basis of the simulation is integrated modeling software Aimsun NG (Xiao et el., 2005) and PTV Vissim that are used in transportation simulations by governments, planners, industry and academia worldwide. These software require prescribing specific models for characterizing features of a given dynamic problem, and uses a built-in library of rules and behaviors to simulate responses to an event. Port operations may be complex and dynamic with many degrees of freedom and uncertainties in initial states. The events or operations may be discrete or continuous. Discrete events may be modeled with the Monte Carlo method to generate a range of possible outcomes and the best solution would be determined using the Brute Force method. Continuous events/operations would be modeled by a set of non-linear differential equations. Resilient states may correspond to equilibrium points of the equations in the parameter space and the resiliency is measured in terms of the departure from that state by a disruption or the time it takes in the parameter space to return to a resilient state. Where the resilient state corresponds to a path in parameter space rather than the equilibrium points of the differential equations, the Viability Theory (Aubin, et al. 2011) of evolution of dynamical systems is used to determine a system that collapses if it departs from a subset of state space called the viability constraints set – optimal paths within the parameter constraints in returning to resilient states within the shortest times are determined through optimization. The model development effort will be carried out in stages and in flexible ways to facilitate verification and to allow making changes to the models.

Quantifying Port Resiliency

The following section discusses how resiliency can be quantified from archival AIS data. This proposed procedure is applied to two empirical case studies: the Galveston Channel closure resulting from a vessel collision and oil spill and the New York/New Jersey Channel closure corresponding to Super Storm Sandy.

Data Collection and Processing

Compilation of MTS travel time statistics for maintained navigable waterways has been initiated for different classes of vessel and by direction (inbound/outbound; upstream/downstream) using a straightforward comparison of the time-stamped position reports as unique vessels move through the various geo-fenced watch areas of interest [5]. Some recent examples of archival AIS data applied in this fashion, as well as practical methods for dealing with some of the issues encountered with travel time outliers can be found in [21] [22] [23]. A similar treatment of AIS data can also be applied to derive dwell time estimates for vessels within a defined bounded region [24]. This can be done by comparing the time stamp of the first observed vessel position report within a defined area to the time stamp of the subsequently first observed report *outside* the defined area. This approach can be applied at a variety of spatial scales, from specific berthing terminals or waterway segments to entire port zones, though care must be taken to ensure the AIS data coverage in the area is thorough and reliable.

Resiliency Parameters

In this effort, vessel location information from onboard AIS transceivers is used to generate two performance indicators, average vessel dwell time within the port areas of interest and net vessel transits into and out of the port areas of interest. Dwell time represents the continuous length of time a vessel spends within the port area or associated regions such as offshore anchorages. In terms of freight throughput efficiency, dwell time indicates the "capability of the port to efficiently handle cargo flows at the terminals and beyond" [25]. Decreases in port performance following a disruption tend to limit the rate at which vessels can be processed, thereby extending the overall average vessel dwell time within the greater port area. The net number of vessels within a port area is obtained from a running tally of vessels both entering and departing the port area and surrounding zones. In the case of port terminals handling cargo, this quantity can indicate relative rates of freight throughput (loading and unloading of vessels) at any point in time; whereas in the case of anchorages where vessels typically wait for berthing slots to open within the port area, this quantity can indicate backlogs and excessive delay owing to disruptions in port operations. It should be noted that there may also be external factors influencing the resiliency performance measures, such as use of anchorages by vessels for reasons (e.g. bunkering and lightering operations) unrelated to the MTS disruption. Here the performance measure (average vessel dwell time and net vessel transits into and out of the port) provide general trends in the efficiency of overall port operations and the associated maintained waterways. By estimating and plotting the resiliency in terms of these two metrics for the days and weeks before and after major disruptive events, additional analysis can be conducted on the recovery efforts and their impact on overall port resiliency and performance.

To demonstrate the versatility of the proposed methodology, four empirical case studies are presented here. The first applies the methodology to a no-notice event (an event with no warning time) that was triggered by a collision between an oceangoing bulk carrier vessel and a tow of fuel barges in the Houston Ship Channel on March 22nd, 2014. The second case study demonstrates the methodology on a short-notice event (warning time is greater than 24 hours), the closure of harbor operations in the greater Port of New York/New Jersey resulting from Superstorm Sandy on October 28th, 2012. The third case study illustrates waterside considerations during a hypothetical short-term closure of Port Everglades due to a storm surge related flooding, while the fourth case study provides the landside consideration in such a case.

Case Study 1: Galveston Channel Closure due to a major oil spill

On 22nd March 2014, the 607-foot long bulk carrier *Summer Wind* collided with a tank-barge being pushed by the *Miss Susan* near the end of the Texas City Dike in Lower Galveston Bay. The collision was caused primarily by heavy fog in the area, and it resulted in about 4,000 barrels (168,000 gallons) of fuel oil spilling into the waterway [26]. During the ensuing channel closure for cleanup operations, pilot services were suspended and ocean-going vessels began queuing up in the various anchorage areas near the entrance to Galveston Bay. This study uses NAIS data covering January-June 2014 for all vessels transiting in the vicinity of the intersection of the Houston Ship Channel with the Gulf Intracoastal Waterway (GIWW). To keep data file sizes and processing times manageable, the temporal sampling rates vary from 5 minutes to 1 hour, depending on the amount of time each vessel was within range of shore-based AIS towers. In Fig. 2, density plots of vessel traffic are shown for the overall Galveston Bay port area (inset) as well as the offshore anchorages where vessels queue up while waiting for pilots and/or berthing slots to open at the various port terminals in Galveston, Texas City, or Houston. The small box in the inset map shows the general location of the collision in March 2014. It should be noted that the density plots reflect relative number of AIS position reports per unit area, but do not necessarily indicate higher numbers of unique vessels. The inbound and outbound traffic fairways can also be seen bisecting the two offshore anchorage areas.

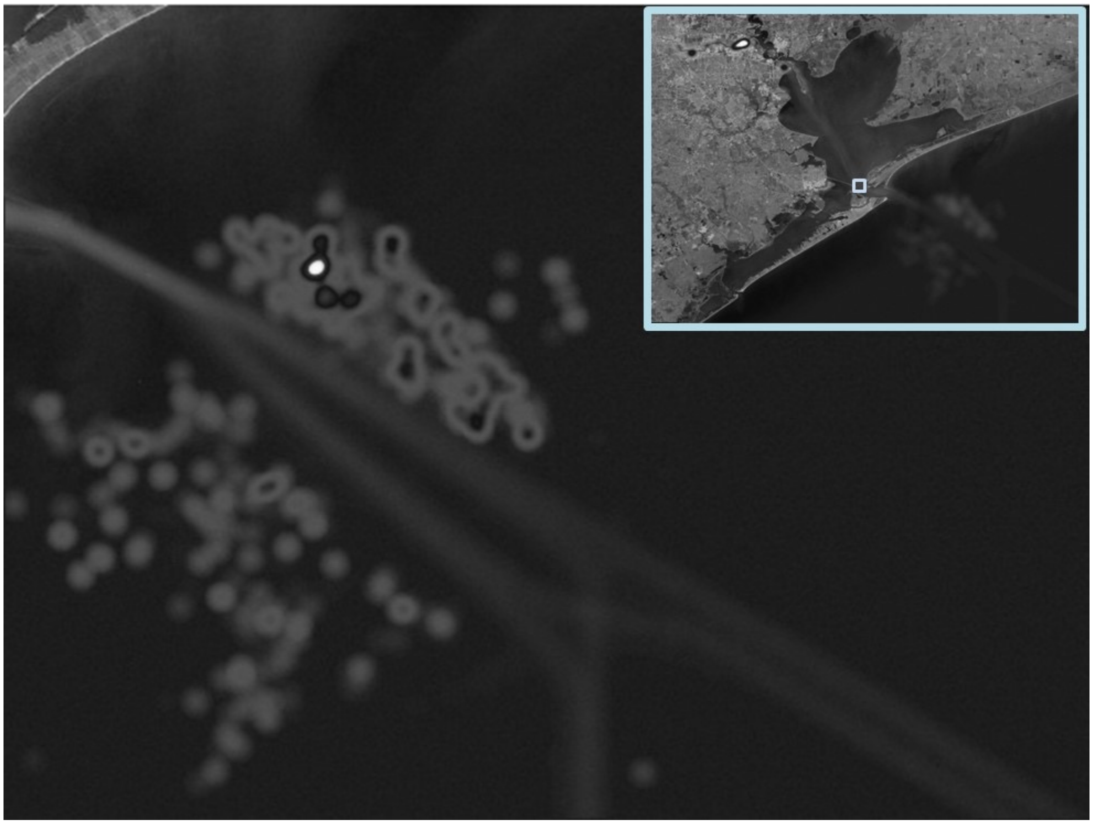

Figure 2: AIS density plot of vessel traffic near the Galveston Entrance Channel

A large watch area encompassing both of the offshore anchorage areas seen in Fig.2 is used as the basis for AIS-derived dwell time observations and a rolling vessel entrance/exit tally during the 6-month study period. As previously described, the dwell time observations are taken as the difference in the time stamps of vessel position reports when first appearing within and subsequently outside of the watch area. Some (manageable) dwell time error is introduced by the differing sampling rates used for unique vessels, which vary between 5 minutes and 1-hr for vessels within range of AIS receiving towers. Figure 3 shows the weekly average vessel dwell times and the number of inbound and outbound vessels within the offshore watch area for the six month period encompassing the vessel collision. The disruptive event date (March 22, 2014) is shown on the figure with a solid line. This period coincides with an imbalance in the number of inbound and outbound vessels and subsequent increases in the average vessel dwell time. An unexpected finding of note includes an earlier increase in average vessel dwell time (noted by the dotted-dashed line) five weeks prior to the collision event. Channel closure records obtained from officials with the Houston-Galveston Vessel Traffic Service (VTS) show that cumulative weekly closure durations were actually higher in February 2014, mostly due to fog, than they were in March 2014, even after taking the post-collision closure into account.

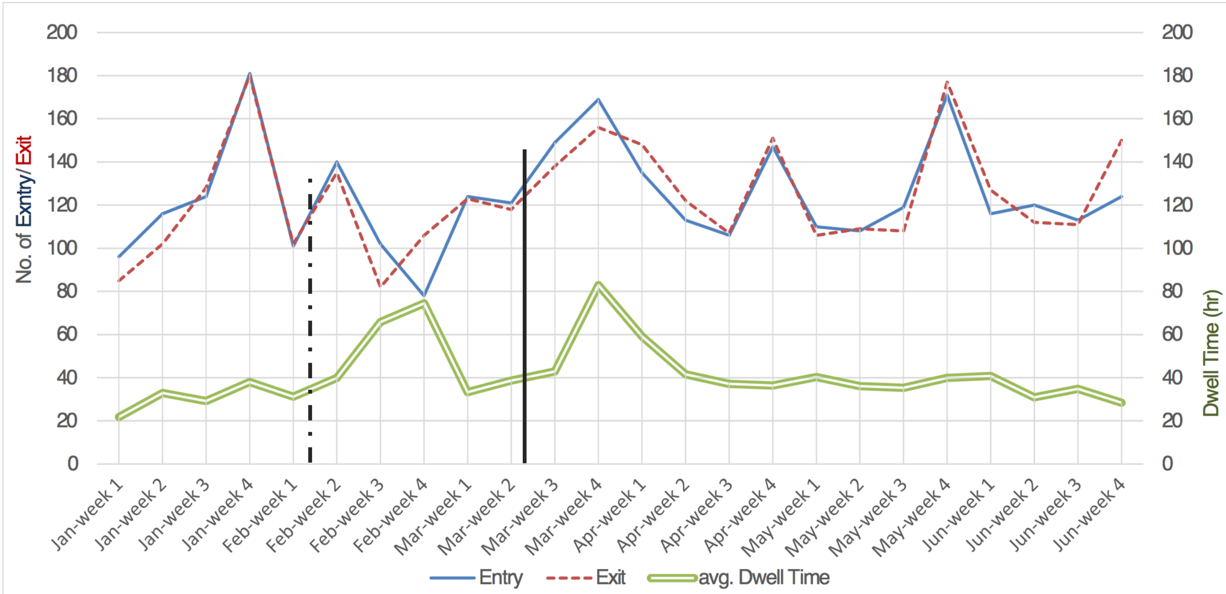

Figure 3: Six-month Vessel Traffic Summary for Galveston Offshore Anchorage Area

Some of the closure durations represent service disruptions in different parts of the greater Galveston Bay port area, and they do not necessarily represent closures of the entire waterway system. The solid line indicates the post-collision disruption that is the focus of this case study. Presumably, the fact that this closure was continuous and affected the entrance to the entire Houston-Galveston-Texas City port zone led to the significant disruptions to overall vessel traffic seen by the average dwell time and net transit count increases in the outer anchorages. However, per the dwell time resiliency results, the multiple closures during February (indicated by dashed line) also appear to have taken their toll on the overall port area performance.

Figure 4 (a) shows the daily average dwell times in the Galveston entrance outer anchorages from March 7, 2014 until April 14, 2014. The event date is shown with a solid line and corresponds to the closure of the channel for a four day period. On March 27, 2014 (shown with a dotted line) the channel was partially reopened and then finally completely opened on April 7, 2014 (shown with a dashed line). The figure shows that prior to the event, the outer anchorage area (the systems, *S*) was in the original state condition. The system reached the full disrupted state starting from March 23, 2014. On Mar 27th a recovery action was taken (the partial reopening of the channel), which began the transition between the disruptive state and the stable state. Finally the system reaches the stable state by around April 7, 2014.

Figure 4 (b) shows the resiliency for each day after the disruptive event. This analysis demonstrates that the recovery action (dotted line) was effective as a means of increasing the resiliency of the system. Then, over the ensuing days the resiliency of the system fluctuates until it again reaches its stable state (dashed line). For this demonstration, the original state is quantified as the average vessel dwell time the day prior to the incident. Future work will incorporate a more statistically robust measure of steady-state, pre-disruption port operations.

Figure 4 (c) shows the daily number of inbound and outbound vessels through the Galveston offshore anchorages for the same period. Also shown in the figure (with solid, dashed, and textured lines) are the event day, partial reopening, and full opening of the channel. Looking at the cumulative inbound and outbound number of vessels, a sharp drop is seen on the incident day. This drop continues (marking the start of the transitional state) until March 25, 2014, where the systems enters the disruptive state. It is important to note that the beginning and ending of the disruptive state occur on the same days as shown in Figure 4(a). After March 26, 2014 the system begins transitioning and by the time of the full reopening on April 7, 2014 the figure is in its stable state.

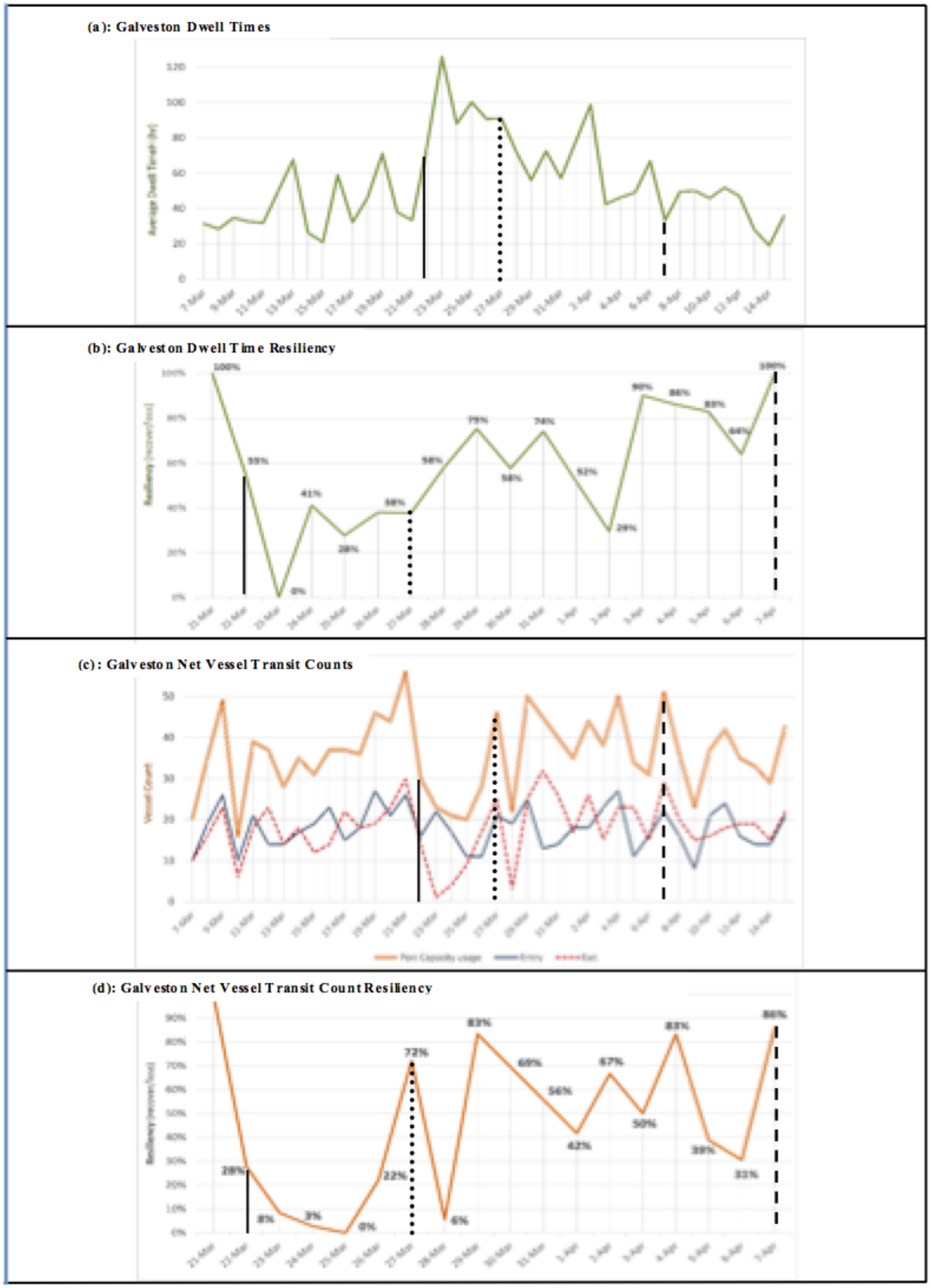

Figure 4. Galveston Bay Performance and Resiliency

Figure 4 (d) displays the daily net vessel count resiliency for the Galveston Bay port area, based on vessels entering and exiting the offshore anchorages. In general, the net transit count resiliency of the system performed in a similar manner to the dwell time resiliency, with corresponding peaks and valleys, to some extent. This is an expected finding considering the relationship between dwell time and the total number of inbound and outbound vessels.

In summary, the vessel collision in the Houston Ship Channel in March 2014 caused a decrease in overall port area performance. NAIS data is used here to quantify the resiliency of the port area operations using two metrics: average anchorage area dwell time and net transit count into and out of the anchorage area.

Case Study 2: Port New York/ New Jersey closure due to Superstorm Sandy

The Port of New York and New Jersey, which spans both the New York and New Jersey sides of New York harbor, is the third largest port in the U.S. and the largest port on the Atlantic coast *(PANYNJ n.d.)*. In late October 2012, New York harbor was significantly disrupted and damaged by Superstorm Sandy as that unusual extra-tropical system moved slowly up the U.S. eastern seaboard. In preparation for the storm, the port was shut down in the evening of October 28, 2012 and remained closed for almost 8 days. For this case study, NAIS data is used for cargo and tankers transiting the Arthur Kill area of New York Harbor during a 6-month (August 2012 – January 2013) period encompassing the landfall of Superstorm Sandy. The sampling rate for unique vessels ranged from 5-minutes to 15 minutes, depending on the amount of time each vessel was within range of AIS receiving towers. Figure 5 shows the AIS density plot of vessel traffic within the greater New York area based on the NAIS data obtained for this study. The small box near the center of the figure shows the area that was queried for NAIS archival data; all vessels transiting this box were tracked for the full 6-month study period. The larger bounded region indicated by the polygon encompassing the greater New York metropolitan area shows the larger port area that was used for the post-Sandy resiliency analysis.

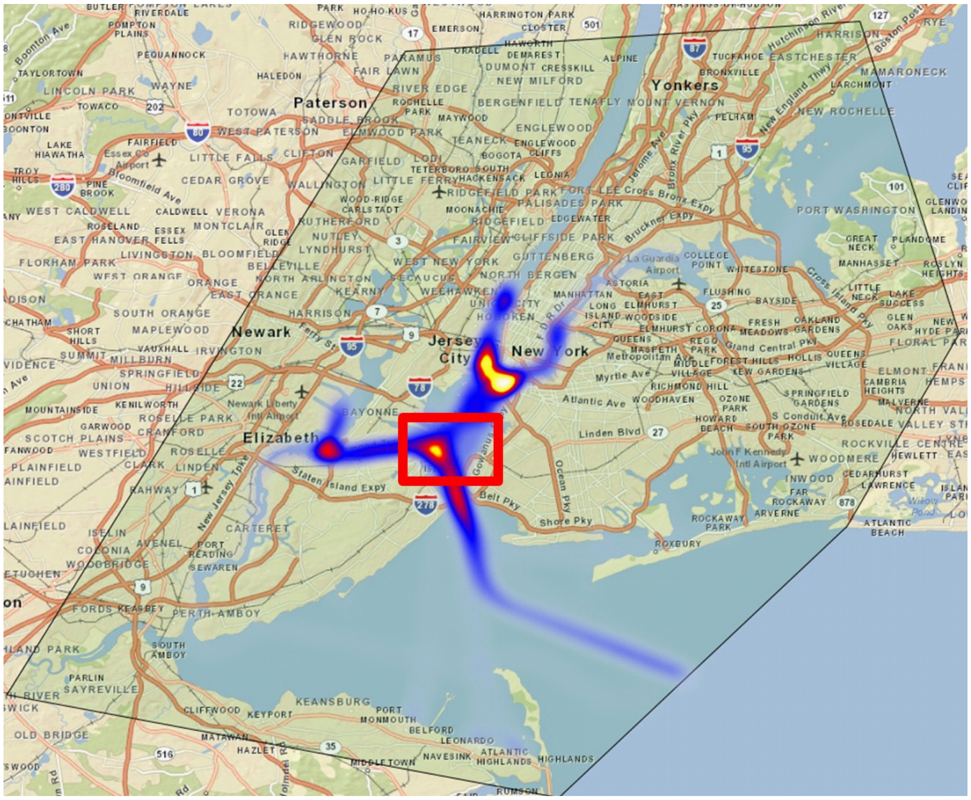

Figure 5 – Density plot of AIS position reports in greater New York Harbor, (smaller) box used for NAIS data collection, and larger polygon used for post-Sandy resiliency analysis

Figure 6 shows the weekly average vessel dwell times and the number of inbound and outbound vessels for New York Harbor during the six-month study period. The day of the closure (October 28, 2012) and the day the harbor was reopened (November 4, 2012) are shown with solid and dashed lines, respectively. In the week leading up to the closure, a drop in the number of vessels can be seen, likely due to vessels routing away from the harbor in advance of the storm. Also shown prior to the closure is an increase in vessel dwell time, also likely due to storm preparations. From the figure it can be seen that the port returns to “normal” operations by the third or fourth week in November.

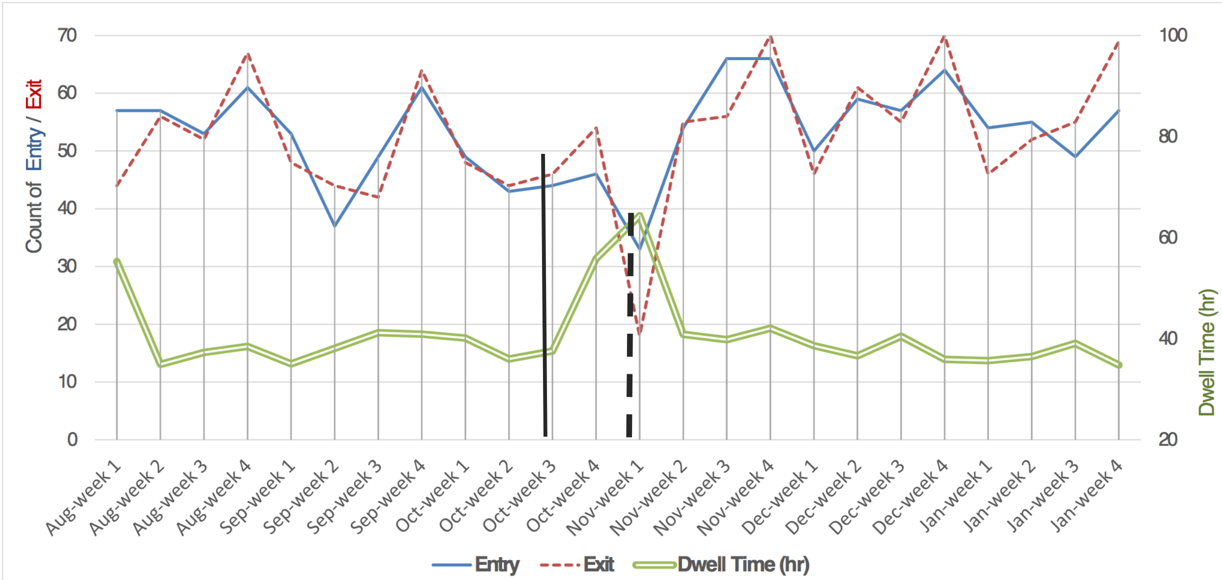

Figure 6: Six-month Vessel Traffic Summary for New York Harbor Area

Figure 7 (a) shows New York Harbor average daily dwell times from Oct. 15, 2012 to Nov. 22, 2012. The closure of the harbor began on Oct. 28 (shown with a solid line), Superstorm Sandy made landfall the following day on Oct. 29, and the port reopened on Nov. 4 (shown on the figure with a dashed line). From the figure is can be seen that vessel dwell times started to decrease a week prior to the incident and that the vessel average dwell times did not immediately increase following the closure. This is in contrast to the no-notice event which took place in Galveston Bay, which saw a drastic increase in dwell times immediately following that incident. However, in the ensuing days after Sandy, average dwell times for the greater New York port area increased as vessels begin to queue, waiting for the port operations to reopen. By Nov. 9, 2012 the port area appears to have returned back to a stable dwell time performance.

Figure 7 (b) shows the dwell time resiliency for each day after the harbor closure. The figure begins on Oct. 27, 2012, the day prior to the closure to provide a reference. The day of the closure and the reopening are shown in the figure (with solid and dashed line, respectively). After the closure, the system transitions to a disruptive state, reaching its maximum on Oct. 31, 2012. The ultimate recovery event was the reopening of the harbor, after which the vessel activity began the transition into a stable state, and essentially normal operating daily average dwell times.

Figure 7 (c) shows the daily number of inbound and outbound vessels through the greater New York port area between Oct. 15 and Nov. 22, 2012. The figure displays the harbor closure and reopening with solid and dashed lines, respectively. Looking at the cumulative inbound and outbound number of vessels, a sharp drop is seen on the day of the closure. Figure 7 (d) displays the daily net vessel transit count resiliency (port serviceability resiliency) for the New York Harbor. Again, as seen during the Galveston Bay disruption, the starting and ending days of the various states in the resiliency process (original state, disruptive state, stable state, and transitive states) are the same between the dwell time and net vessel count resiliency figures.

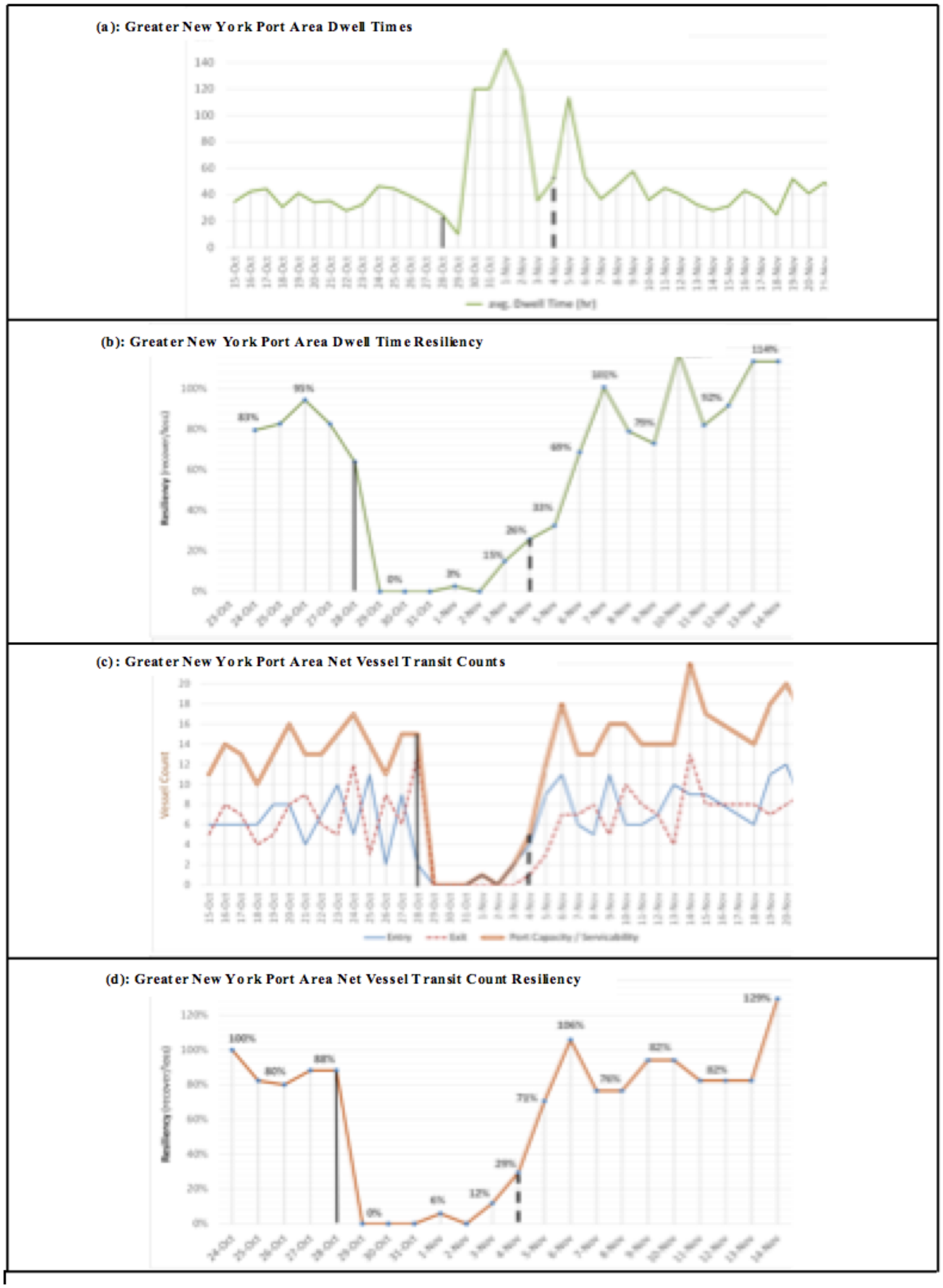

Figure 7. Greater New York Port area performance and resiliency

When comparing case studies 1 and 2 from a resiliency standpoint, several notable differences can be seen. First, in the days leading up to Superstorm Sandy, there was a gradual increase in the number of exiting vessels. This shows that many of the large tankers and cargo ships evacuated prior to the arrival of the storm. No such evacuation was possible prior to the incident that took place in Galveston Bay. Also, since the New York Harbor closure was scheduled in preparation for the storm, the drop off in port performance was drastic. This is in contrast to the Galveston Bay example, in which vessels were still able to access the anchorage areas offshore of the Galveston Entrance channel both before and after the incident. This manifested itself in a more gradual drop off in port system performance. Furthermore, it would appear that approximately 48-72 hours after New York Harbor was reopened, the vessel traffic and dwell times returned to a pre-event levels. The same cannot be said for the no-warning event in Galveston Bay, where normal port operations did not resume until several days later.

<u>Case Study 3: Simulated Closure at Port Everglades due to Flooding (Waterside)</u>

This section illustrates the port waterside simulation model development which is currently underway. The project team is currently developing three Monte Carlo simulations for Port Everglades, FL, the Port of Long Beach, CA and the Port of New Orleans, LA. Fundamentally, Monte Carlo simulations work by estimating unknown values based probability distributions. Effectively, vessel arrivals and departures are random variables, however, they can be accurately estimated if enough observations are available. Therefore, using this statistical tool it is possible to generate random arrivals and dwell times that statistically match observed port operations. In effect this procedure allows for the generation of a “typical” day, week, or month of vessel traffic that is statistically indistinguishable from reality. The data collected for the development of the Monte Carlo simulation, and how they are being processed is described below. The impact of a simulated hypothetical flooding event at Port Everglades is demonstrated using these data and the results of a deterministic analysis is presented as an example.

Data Collection

Due to the volume of the data needed to develop the Monte Carlo simulation of the three ports (Port Everglades, Port of New Orleans and Port of Long Beach), 12 months of AIS data from each port was purchased from MarineTraffic.com. The data contains 160,180 records of vessel arrivals, departures, and dwell time starting July 1st, 2015 and ending June 30th, 2016. For all practical purposes, this data is identical to that provided by the U.S. Army Corps of Engineers (USACE) described earlier.

Monte Carlo Simulation Approach

The vessel data is currently being analysed to identify probability distributions of vessel arrivals and dwell time by cargo type and time of day. From this analysis it will be possible to determine, with quantifiable accuracy, the probability of a vessel arrival, its dwell time, and its cargo type. For example, it is possible to estimate the likelihood of a container vessel arriving between 7:00 and 7:30 AM and dwelling for 25 to 26 hours before departing. From this information, the Monte Carlo simulation generates random arrivals and dwell times which correspond to the observed probabilities. This simulated vessel timetable can be directly programed into a microscopic traffic simulation software.

Simulated Resiliency

A two-day flooding event was simulated at Port Everglades beginning June 30th and ending July 2nd. In this scenario, six of the eight container terminals located to the south of the port are considered damaged by flooding and are inoperable for a 48-hour period. As a result, all container vessels arriving during this period are shifted to the two operable terminals located in the northern portion of the port. After the 48-hour period, the damaged terminals are restored to full operation. This event has caused a backlog of container vessels waiting to be unloaded. Port operators are faced with a decision: 1) continue to work on 12-hour shift or 2) move to a 24-hour shirt until the backlog is addressed. Using the dwell time resiliency procedure described in the previous chapter, the 12-hour operations scenario is plotted in figure 8 (a) and the 24-hour plot is shown in figure 8 (b). This analysis assumes that loading and unload are unaffected by the flooding scenario (i.e., the terminals are no more or less effective as a result of the flooding).

Both Figure 8 (a) and Figure 8 (b) show port operations on June 29th and then a sharp drop off in service resulting from the flooding. The port remains in the disruptive state, in both figures until the recovery action of reopening the damaged terminals is taken. Figure 8 (a) shows that on a 12-hour work schedule it will take six days to service the backlog of vessels caused by the flooding as compared to less than three days if a 24-hour work schedule is adopted. The differences in resiliency between these two approaches is most notable by the drastic difference in the recover curve slopes, seen after the reopening of the terminal on July 2nd. If port operators determine that a six-day recovery is unacceptable from a two-day flooding event, it would be advisable to develop plans to implement a 24-hour emergency shift schedule and to have port workers on call in the days after a flooding event to improve the resiliency of the port. This simple example clearly demonstrates the need for quantitative analysis in resiliency planning and allows for a more rigorous evaluation of the cost and benefits associated for resiliency strategies.

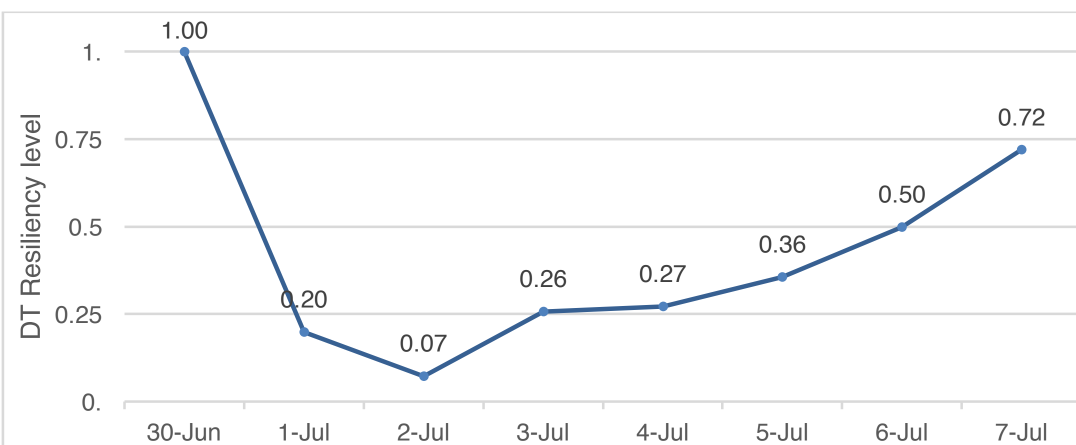

Figure 8 (a): Port Everglades Estimated Resiliency for 12 Operations

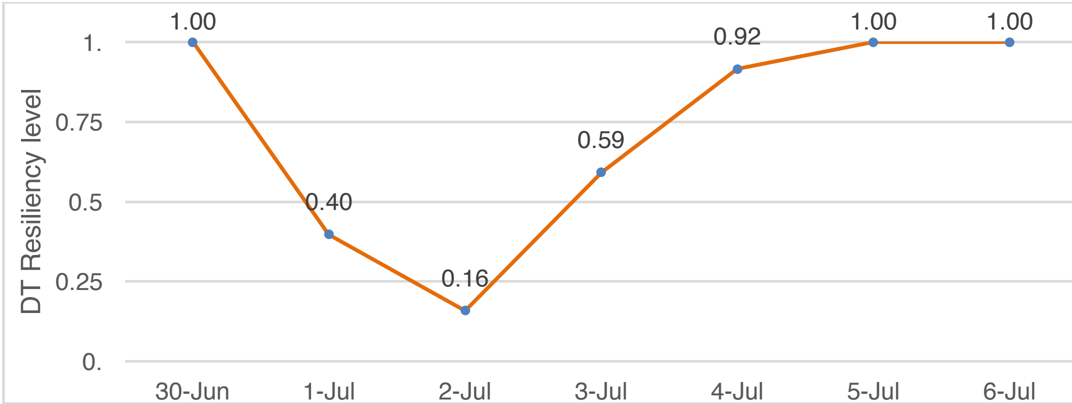

Figure 8 (b): Port Everglades Estimated Resiliency for 24 Operations

For case study, Automatic Identification System (AIS) data have been utilized to create new methods and metrics for the assessment of resiliency in maritime systems. This methodology advances the field of disaster science by expanding on the concepts first proposed by Henry and Ramirez-Marquez (2012) and Baroud et al. (2014), and applying these methods to empirical observations.

In general, the results of the research show that AIS data is an excellent source for quantitative data when seeking post-disaster measures of resiliency. The time dependent performance models developed from this data show the cascading effects of disruptions and quantify the benefits gained by recovery efforts in a time-progressive series. One of the more interesting findings of this effort was the manner in which the data show, in quantifiable terms, reductions in performance resulting from incremental, less-publicized disruptions (Feb. 2014 at Galveston Bay) and evidence, albeit limited, of the benefits of advanced warning prior to a disruptive event. It is worth noting that the proposed approach can also be applied toward longer-period disruptions. The recent West Coast labor dispute and associated port slowdowns in late 2014 and early 2015 provide a prime example of the need for unbiased analysis and can be studied within the context of this research in future work.

While work is still being conducted on developing the Monte Carlo simulation models for the three case study ports, the deterministic example provided here demonstrates the ultimate utility of evaluating resiliency strategies. The need for accurate and robust metrics for estimating resiliency in simulated scenarios is necessary to determine what actions will have the greatest effect on port resiliency. Once complete, the developed methods and models can be applied to evaluate any number of disruptive scenarios, from sea-level-rise to acts of terrorism. These models will also allow port operators to evaluate a wide range of recover strategies and plans to increase the resiliency of their facilities.

On a broad level, these findings also represent some of the first steps toward the development of standardized metrics for quantifying MTS operational resiliency. The use of AIS data, which collects information from nearly all commercial vessels on a semi-continuous basis, is a rich data source with many applications in disaster science. The methods developed and applied here incorporate an all-hazards approach to quantifying resiliency in navigable waters and can be applied across a range of temporal and spatial scales.

<u>Case Study 4: Simulated Closure at Port Everglades due to Flooding (Port and Landside)</u>

Based on modeling Port Everglades' existing infrastructure, the research team developed a simulation of its operations, in support of improved planning decisions, efficiency and productivity. A micro-simulation model of the port and landside region was developed including the port and the surrounding area. Port Everglades has 3 zones indicated by purple circles in Figure 9 and a total of 6 gates indicated by blue boxes were. These areas were taken as the foci of the simulation. The zones are added to produce the traffic, gates are inserted to consume the traffic produced by zones and paths were created from the zone to the gates.

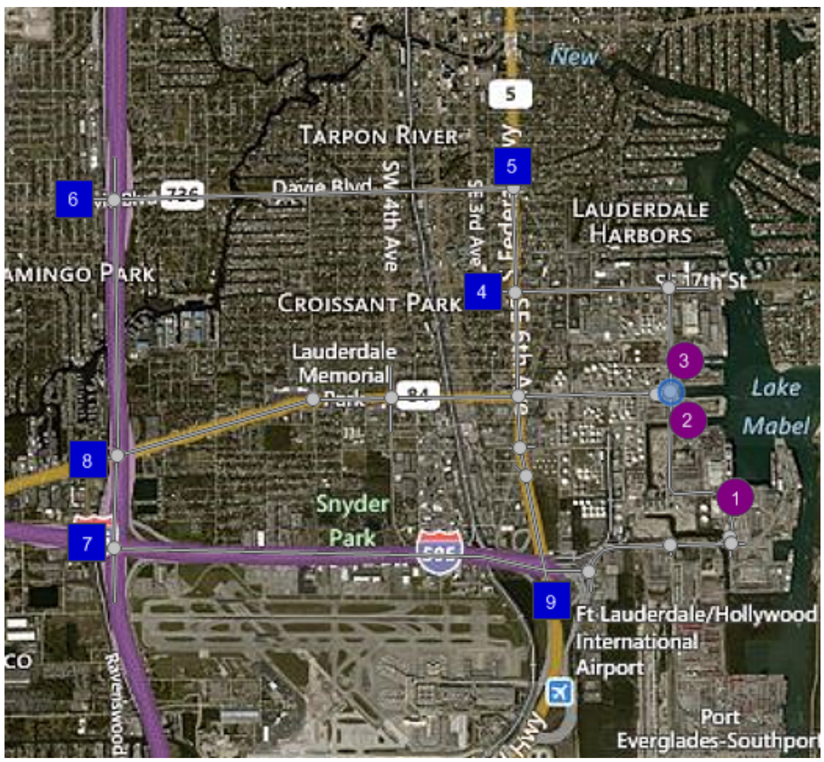

Figure 9- Location of Gates & Zones

In our methodology we developed a trip generation and distribution model for freight transportation using the existing truck network. The prevailing conditions modeled consisted of 3,756 generated trips for the surrounding facilities and a minimum of 3,040 trips were generated from Port Everglades on a daily basis. The AM peak hour is 1,919 and 1,600 trips between zones 2 and 3. The AM peak hour was calculated at a total of 1,761 trips

The area consists of two major exit passageways: at I-595 and US Highway 1 leading west and north out of the city. At this point we developed a complete and thorough traffic analysis for Port Everglades based on the existing condition in case of flooding for the entrance of the port regarding the FEMA sea-level maps. Deriving optimal traffic management schemes for urban road networks typically relies on the use of microscopic simulation tools that capture in detail the behavior of drivers as well as their interaction with the network infrastructure. These simulation tools can provide accurate network performance estimates in the context of scenario-based analysis or sensitivity analysis.

Once we accomplished optimizing the existing condition, we developed a simulated method to keep the Port in functioning order: in the event of flooding takes place in zone 1, both zones 2 and 3 will be utilized for access pathways to and from the port until zone 1 has been resolved. In the event zone 2 and 3 are not operational due to flooding, zone 1, which is designated as best connected to I-595, is used as the main access point to keep the Port functioning as shown in Figure 10. In the event of the worst-case scenario involving flooding affecting all the zones, Continuity of Operations Planning (COOP) would be put into place to balancing the needs of all customers.

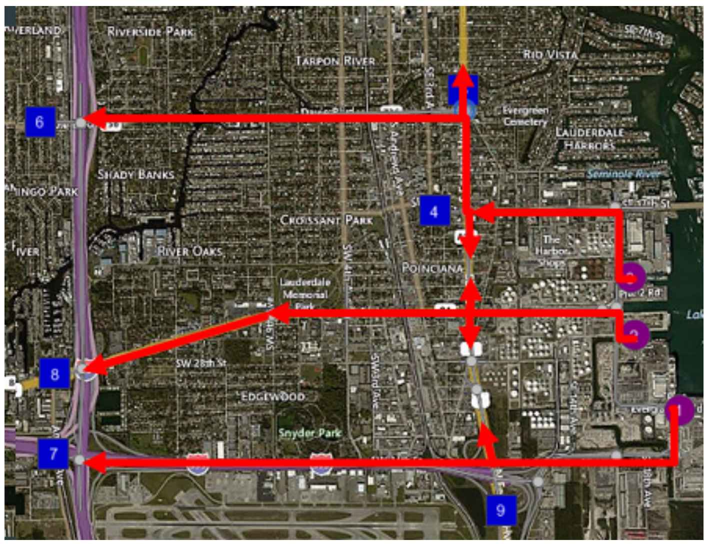

Figure 10 - Exit Strategy

The Federal Emergency Management Agency (FEMA) provided the flood maps for Port Everglades on their Map Service Center (MSC) government website (Figure 11). The flood maps display the various potential flood zones and there unique characteristics in relation to flooding. The various characteristics include the flood depths, the chance of flooding for specific zones and areas, which are protected from certain flood events by a federal flood protection system. The port of Everglades entails unique features when flooding occurs around the port. There are 2 distinctive characteristics given in these flood maps that make it fairly easy to determine the areas of risk. These are areas shaded in light blue and areas shaded in black. The areas for which we will direct our concern to the most will be the highlighted blue as they represent a 1% annual chance of flooding. This might take place given a strong storm surge associated with a hurricane of high enough category. The areas shaded in black represent areas for which the elevation is below 1-ft on average. These parts are either protected by levee systems, which will reduce the flooding chance to a minor 0.2% given that the areas shaded blue where to actually hit the 1% chance and flood. The area that is more likely to flood first for the port is contained in zone AE, SE 25th St and SE 26th St., which leads to Eisenhower Blvd just west to become unavailable

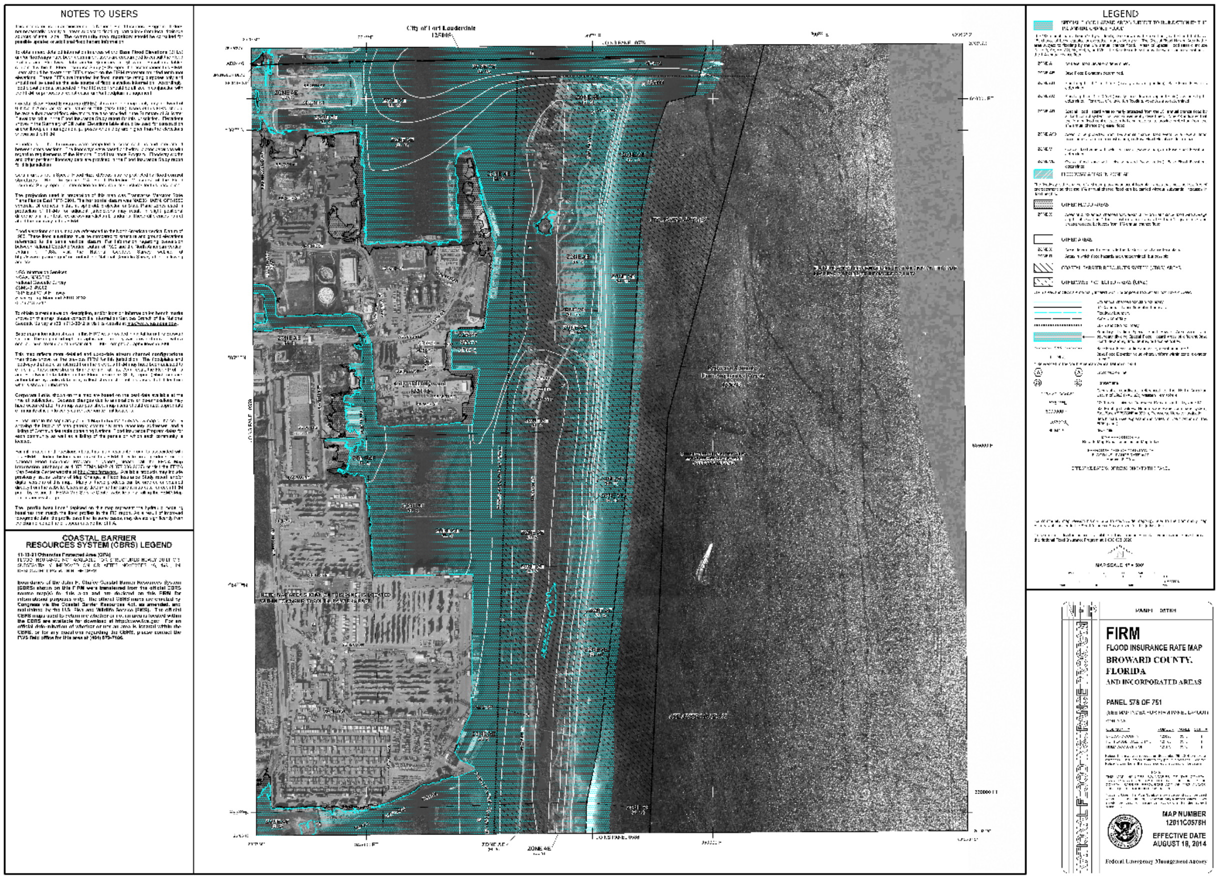

Figure 11 – FEMA Map

Also, four traffic methodologies (Do Nothing/ Nearest Two Exits, Destination Capacity / Management, Reference and Staged Evacuation) were tested for the purpose of this case study. Destinations Capacity and Management methodology assumes that a pre-defined evacuation plan is available. This evacuation plan will only tell the evacuees which exit to use, based on the capacity of each exit. This will cause a small increase in the information dispersion process according to the 'Do Nothing' strategy. As a result, the evacuees' rationality will increase. However, the rationality is still low, causing panicking evacuees. They still compete for the egress routes without considering others and evacuate as soon as possible. The evacuees will be distributed over the available exits regarding their capacity, in a certain way to minimize the total vehicle travel. To accomplish this, the shortest path is taken into account in the calculation. The shortest path is in this case is the route with the shortest travel time. This will result in converging and some diverging traffic flows, decreasing the traffic delay at intersections. As in the 'Doing Nothing' strategy, the evacuees are free to choose their route within the available network area and the usable exits are constrained. A reference methodology simulates evacuees that will be distributed over the available exits regarding their relative attraction. The relative attraction of some specific exits is larger than others, because these exits are related to major roads, which are able to lead traffic out of the urban area. It is assumed that evacuees incline to use these exits more. It is also possible that a pre-defined evacuation plan will tell the evacuees which exits are more likely to use than others.

Staged is a common methodology in transportation management wherein the city is divided into zones. These zones are then grouped together according to level of proximity to disaster. Those residing in zones that are in the most danger (closest proximity) are evacuated first. All zones in contact with the pre-selected zones that are evacuated first are evacuated second. All other zones that are not directly adjacent to the zones in immediate danger are evacuated first as well. This type of strategy considers staggered evacuation and schedules a series of evacuations between origin nodes and safety destinations. A dynamic network assignment is imposed so as not to overload the network at any one time. It is hoped that this strategy would provide an organized evacuation route for all directly involved and congestion might be delayed (see Figure 12).

Figure 12 – Micro-simulation Example

Analyses of the results of the simulation of this case study are underway.

<u>Case Study 5: Simulated closure of Port of LA (POLA) due to a labor dispute</u>

The POLA is now the leading gateway for trade between the U.S. and Asia, with the largest workforce of skilled long shore labor, warehouse and trans-loading centers to meet the needs of every shipper, and rail connections that offer frequency and speed-to-market access to major freight hubs across the United States. The Port, also known as America's Port, is a complex that occupies 7,500 acres of land and water along 43 miles of waterfront and adjoins the Port of Long Beach. The Port is approximately 20 miles south of downtown LA; it employs nearly 896,000 workers throughout the county region and 3.6 million workers worldwide. An event which can significantly affect the Port's movement of goods is a strike, or labor strike – a work stoppage caused by the mass refusal of employees to work.

Decision making

Because of the predictability of a strike, actions can be taken to minimize the effects of the port shutting down completely. One of the first thing that can be done would be to establish a port coordination team (PCT) and within that team, designate a leading officer. This provides any port disruption event with a group of people that can establish incoming container priorities, management of vessel movements, preservation of safety and security, and implementation of emergency protocols. Another course of action is to expedite the essential operations of the port up to 4 weeks before the anticipated strike to increase the storage capacity inside the port. The goal of expediting orders is to achieve at least a 75% available storage space; this increase in storage capacity will allow for incoming trucks and ships to place their containers into storage after the strike and reduces the need to redirect business to other ports. A tentative plan has been devised in order to simulate as efficiently re-open the port operations and ultimately reduce the backlog of ships which are ready to unload cargo.

The simulation assumes that the POLA re-opens at 7 a.m. the business day following a 24-hour-strike. Prior to the port re-opening, truckers, trucking companies, ships, rail lines, emergency responders, and all port employees are informed of:

1. The plan for prioritizing of cargo and entering and exiting of trucks. This allows the trucking companies and truckers to reroute and reduce some incoming trucks to enter the queue.
2. Available warehouse services for those who are able to place their cargo into storage.
3. Key emergency contacts and where the emergency responders (such as State Police) are stationed.

All of these steps are proposed to ultimately keep the in gate process time to under an hour which is about the average time. In the past worker strikes, idling times for trucks were in excess of 4 hours at times. This led to fuel waste, additional harm to the environment through exhaust, and congested roadways that restricted movement for emergency vehicles. Also, the port will have made a determination on what cargo is most time sensitive, such as perishables, or other items which are vital for the local and national economies.

1. First trucks to enter the port terminals will be notified, they are trucks that have existing cargo containers at a terminal berth which are needed to be moved in order to open up space for the next ship waiting off shore.
2. The cargo, which requires cold storage, will be prioritized highly and ordered to the applicable terminal berth as soon as the initial existing cargo is released.
3. All trucks entering the port must have an appointment.
4. A fee reduction will be made for trucks that are able to set a pickup appointment outside of peak hours which are from 12pm to 7pm. This will spread the traffic flow out and allow for shorten processing time inside the terminal and getting trucks on their way faster.
5. Offer warehouse services for those who are able to store their cargo at the port or any of the intermodal transfer facilities. This will minimize the immediate truck volume shock to the port.
6. With the 75% of the port’s storage capacity available, the port can store up to 3300 40-ft containers of dry bulk and up to 130 storage tanks of liquid bulk
7. Through effective communication prior to trucker’s arrival at terminal gates, ways to pre-screen them so that the check in process is reduced, thus reducing the time inside of the terminal.

8. Any truck that has a final delivery destination outside of the City of Los Angeles will be required to pick up their cargo at the intermodal transfer facilities which are accessible via railway. This will not inconvenience them while also limiting the truck flow to the port terminals.
9. Steps will be prepared to divert select cargo ships which are still in transit to the Los Angeles Port. San Diego and Oakland are viable options for this diversion.
10. Consider waiving off the Jones Act which limits the flexibility of diverting cargo to other ports.
11. Anticipate the declaration of Force Majeure which permit ships to not be responsible for any obligations under contract when there's circumstances beyond their control. Examples include war, strike, piracy and natural disasters.
12. All of the terminals are independently owned and operated, however the PCT will strongly encourage the terminals to extend operating hours in the short-term to more effectively reduce the back-log of containers.
13. State Police will be stationed at all of the terminal entrances, and at certain points along the major roadways entering and exiting the port.
14. All trucks entering the port must use either Interstate I-110 or Interstate I-710 according to where they are picking up cargo. Any pickups at Terminal Island will absolutely have to navigate to the terminal via I-110. Any cargo pickup at Pier 400 will need to arrive via I-710.
15. The Vissim micro-simulation platform should be done to determine the best possible route for exiting the Port of Los Angeles: via I-110 or Terminal Island Freeway/SR-10.

Cargo Rerouting During Strike

During the 24-hour strike alternative routing locations have been evaluated to limit the amount of cargo that needs distributed from the port once the strike has finished. Several surrounding ports have been found to be candidates to receive a percentage of the expected cargo during the 24-hour strike period. This section of the report expounds on these possible candidates; however, prior agreements must be made between the POLB/POLA and the proposed ports as part of the resilience plan. A total of 15-percent of the total cargo anticipated in the 24-hour strike period was estimated to be rerouted, estimated percentages have been made as to how much of the anticipated cargo could be rerouted to the individual surrounding ports.

The first step in the simulation development is for the team to collect the necessary data and information. The general information about Port of Los Angeles and its daily operation were gathered to gain an understanding of the current condition of the port. The information about the traffic flow, major routes entering and exiting the port, cargo trucks routes and signal timing were determined for the simulation of the road network. PTV Vissim 7 has been chosen to model the Port of Los Angeles. The entire port is modeled to include Interstate 170 and State Road 103. PTV Vissim has been chosen because of the accurate data collection tools and parameters to stimulate different types of intersections. The program is also very user friendly and can provide results in a useable form in this project. Vissim is first used to stimulate the current traffic conditions of the Port of Los Angeles. After analyzing the port's current conditions, the team will create a resilience plan to assist the port in achieving normal operation after a 24 hour strike. The resilience plan includes both before and after strike actions for the Port of Los Angeles take – such as expediting orders four weeks before the anticipated strike. One of the step the port should do after the strike is to determine the best possible route to exit the port. The plan is to stimulate two more models to determine the quickest way for the trucks to exit the port via I-110 or SR-103. Using the exiting route the team can determine the shortest time it takes for the Port of Los Angeles to return back to normal operation. Because some assumptions are made when creating the simulations and the resilience plan, a solution in responding to the labor strike can be proposed.

In order to develop a resiliency plan a simulation model was created. PVT Vissim 7.0 was used for this simulation. The first step to create an accurate simulation was to obtain traffic volume counts for all major freeways near the Port of Los Angeles. Traffic counts were obtained from the San Pedro Community Plan. The entire network that was simulated is outlined in red in Figure 13. It was assumed that at least 60 percent of trucks that were traveling on SR-47 would exit the freeway on Ferry St. or Navy Way to drop off cargo (Figure 2). Intersection traffic signalization was implemented for three intersections (SR-47 & Ferry St., SR-47 & Navy Way, and SR-47 & Terminal Island Freeway). After all inputs were entered into the program the current conditions for the Port of Los Angeles was found and the results can be seen on Table 1.

As mentioned previously, the Port of Los Angeles is known to create significant traffic congestion. Table 1 shows how even during regular operations all freeways and intersections are categorized as level of service D. Level of service D symbolizes unstable flow and some tolerable delay.

Table 1: Delay Study Current Conditions

Current Conditions

Time Interval (s)	Delay Avg (all) (sec/veh)	Stop Avg (All) (S)	LOS
0-900	43.59	0.55	D
900-1800	47.79	0.58	D
1800-2700	46.88	0.55	D
2700-3600	43.22	0.54	D
3600-4500	44.92	0.55	D
Total	227.08	2.78	-
Average	37.85	0.46	D
Standard deviation	18.30	0.22	-
Minimum	0.68	0.01	-
Maximum	47.79	0.58	-

The next step for the simulation was to implement two case scenarios. In the first case scenario gate 1 and gate 2 (figure 1) were completely shut down. Once all roads were completely backed up, gate number one was open simulating the re-opening of the port after the strike.

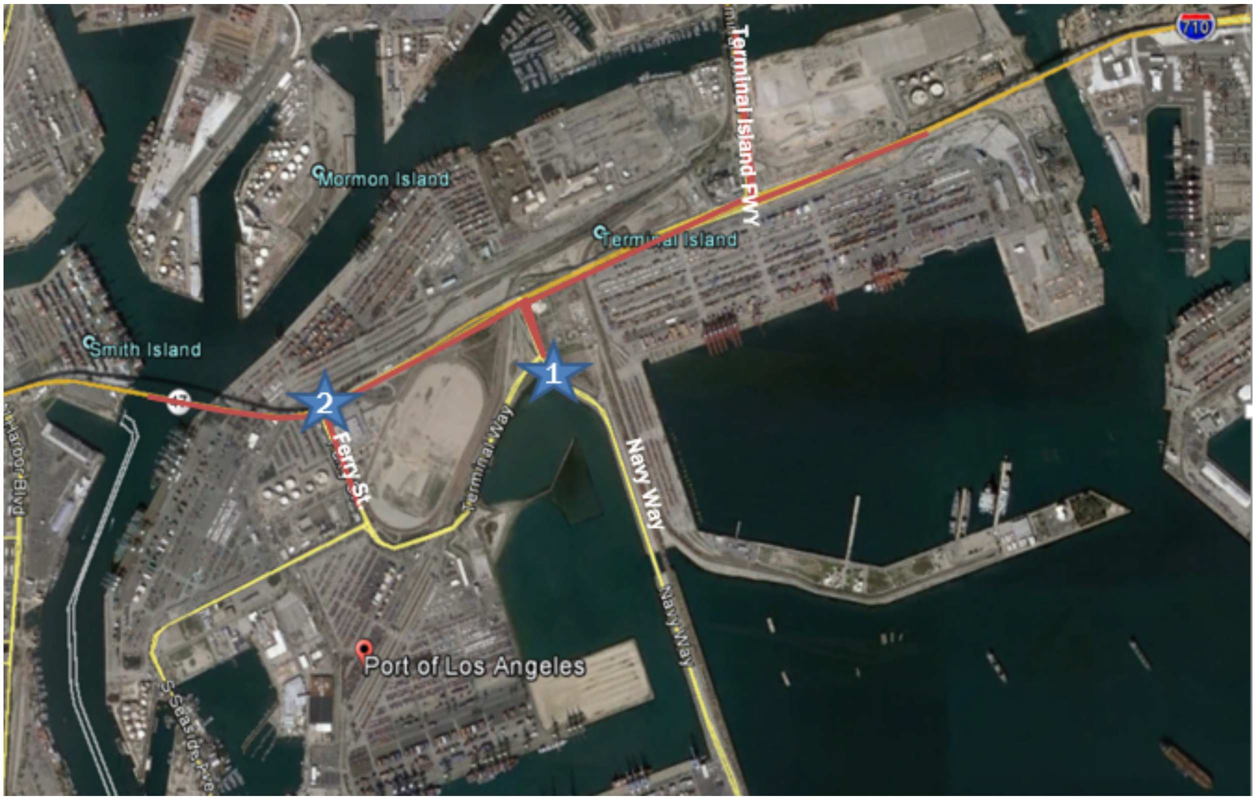

Figure 13: Port of Los Angeles Simulation Routes

The simulation was run for at least one hour after only gate one was re-opened. The results for case scenario one are shown on Table 2.

Table 2: Case Scenario 1

SCENARIO 1

Time Interval (s)	Delay Avg (all) (sec/veh)	Stop Avg (All) (S)	LOS
0-900	220.37	1.03	F
900-1800	241.13	1.43	F
1800-2700	256.38	1.41	F
2700-3600	308.49	1.07	F
3600-4500	343.06	1.06	F
Total	1369.82	6.00	-
Average	228.30	1.00	F
Standard deviation	120.47	0.52	-
Minimum	0.38	0.00	-
Maximum	343.06	1.43	-

Scenario # 1 includes only opening gate # 1
Gate # 1 is located on US 47 & Navy Way.

Table 2 shows the level of Service after only re-opening gate number one the average stop time for all vehicles was 1 second. In the next case scenario (case scenario 2) again gate 1 and gate 2 (figure 2) were completely shut down. Once all roads were completely backed up, gate number two was open simulating the re-opening of the port after the strike. The simulation was run for at least one hour after only gate two was re-opened. The results for case scenario two are shown on Table 3.

Table 3: Case Scenario 2

SCENARIO 2

Time Interval (s)	Delay Avg (all) (sec/veh)	Stop Avg (All) (S)	LOS
0-900	187.94	1.10	F
900-1800	317.83	1.23	F
1800-2700	413.57	1.59	F
2700-3600	409.07	1.63	F
3600-4500	423.85	1.65	F
Total	1752.85	7.19	-
Average	292.14	1.20	F
Standard deviation	168.69	0.63	-
Minimum	0.59	0.00	-
Maximum	423.85	1.65	-

Scenario # 2 includes only opening gate # 2
Gate # 2 is located on US 47 & Ferry St.

Table 3 shows the level of Service after only re-opening gate number two the average stop time for all vehicles was 1.2 seconds. It was also discovered while performing the second case scenario that although gate number 2 was open, there was still a higher vehicle delay due to the traffic congestion on gate number one. Even though the average stop times were very close in both case scenarios, when running case scenario number two the vehicles trying to exit the Port of Los Angeles on the intersection of SR-47 and Ferry St. were not able to enter the interstate; even when the traffic signals were green. Therefore, the best route option for trucks that will be carrying critical cargo (all cargo that requires refrigeration) and emergency vehicles will be to use gate number one.

We stored a few samples of simulation results for current and a couple different scenarios (see Appendix 1). A simulation model was executed for the existing traffic conditions, which would be equivalent to a time prior to the port worker strike see Table 4). The level of service based on simulation was at a level of service D. Thus, traffic flow seems to be difficult in this area of the port, even when the port is operating normally. Next, we tested the model when the terminal island is closed down and forced all of the traffic down Navy Way (Option 1) in order to gain access to Pier 300 and Pier 400. Example of this simulation work is Figure 14. After evaluating the results from this simulation, a level of service F was concluded for the Navy Way entrance (Option 2; see figure 15). Another scenario was then set up for simulation to compare which roadway was more vital to the level of service for traffic. The entrance into Pier 400 which is Navy Way (Option 1) was then closed off and all incoming traffic was forced to enter through Ferry Street (Option 2). This simulation also produced a level of service to be an F, similar to the first roadway shutdown. Instead of showing this complex chart, can't you just make a summary statement?

Table 4: Time Simulation

CURRENT CONDITIONS														
Sim-run	Time Interval	Delay Avg (all) (sec/veh)	Stop Avg (All) (S)	Speed Avg (All)	Delay Stop Avg (All)	Dist Tot (All)	Trav Tm Tot (All)	Delay Tot (All)	Stops Tot (All)	Delay Stop Tot (All)	Veh Act (All)	Veh Arr (All)	Delay Lantent	Demand Lantent
1	0-900	43.59	0.55	51.32	25.00	5901.78	413992.50	97038.17	1230.00	55640.75	542.00	1684.00	619.55	1.00
1	900-1800	47.79	0.58	48.00	26.87	6870.92	515287.55	138015.90	1681.00	77597.72	631.00	2257.00	596.65	2.00
1	1800-2700	46.88	0.55	48.94	26.54	6930.28	509743.20	135398.79	1595.00	76635.65	568.00	2320.00	564.00	1.00
1	2700-3600	43.22	0.54	49.49	25.37	6491.05	472133.35	117998.01	1470.00	69267.42	503.00	2227.00	421.85	1.00
1	3600-4500	44.92	0.55	49.94	25.06	6680.71	481634.90	122626.76	1494.00	68417.36	582.00	2148.00	503.70	1.00
1	Total	227.08	2.78	295.76	129.28	32893.02	2394160.15	611477.33	7475.00	347822.10	3409.00	10643.00	2706.05	7.00
1	Average	37.85	0.46	49.29	21.55	5482.17	399026.69	101912.89	1246.00	57970.35	568.00	1774.00	451.01	1.17
1	Standard deviation	18.30	0.22	1.25	10.37	2702.23	198141.02	51848.28	627.00	29345.98	43.00	895.00	232.01	0.41
1	Minimum	0.68	0.01	48.00	0.45	18.27	1368.65	399.69	5.00	263.20	503.00	7.00	0.30	1.00
1	Maximum	47.79	0.58	51.32	26.87	6930.28	515287.55	138015.90	1681.00	77597.72	631.00	2320.00	619.55	2.00

CASE SCENARIO ONE														
Sim-run	Time Interval	Delay Avg (all) (sec/veh)	Stop Avg (All) (S)	Speed Avg (All)	Delay Stop Avg (All)	Dist Tot (All)	Trav Tm Tot (All)	Delay Tot (All)	Stops Tot (All)	Delay Stop Tot (All)	Veh Act (All)	Veh Arr (All)	Delay Lantent	Demand Lantent
2	0-900	220.37	1.03	24.08	176.43	4768.65	712929.10	459037.48	2140.00	367509.26	1326.00	757.00	35788.10	144.00
2	900-1800	241.13	1.43	19.56	131.14	6387.36	1175345.80	809489.52	4788.00	440243.99	1272.00	2085.00	211806.85	461.00
2	1800-2700	256.38	1.41	18.93	154.21	5821.27	1106827.50	788119.22	4343.00	474049.99	1266.00	1808.00	621753.35	915.00
2	2700-3600	308.49	1.07	14.47	215.88	4801.79	1194607.25	943061.79	3260.00	659951.06	1370.00	1687.00	989647.35	1286.00
2	3600-4500	343.06	1.06	12.58	245.97	4610.15	1319396.65	1079941.62	3352.00	774302.96	1630.00	1518.00	1367928.30	1737.00
2	Total	1369.82	6.00	100.80	923.90	26391.50	5509840.45	4080274.33	17884.00	2716490.71	8495.00	7856.00	3227705.20	6279.00
2	Average	228.30	1.00	16.80	153.98	4398.58	918306.74	680045.72	2981.00	452748.45	1416.00	1309.00	537950.87	1046.50
2	Standard deviation	120.47	0.52	4.90	85.96	2265.00	494559.13	391915.13	1728.00	267878.68	171.00	781.00	556238.02	660.93
2	Minimum	0.38	0.00	11.18	0.27	2.28	734.15	624.70	1.00	433.45	1266.00	1.00	781.25	144.00
2	Maximum	343.06	1.43	24.08	245.97	6387.36	1319396.65	1079941.62	4788.00	774302.96	1631.00	2085.00	1367928.30	1737.00

CASE SCENARIO TWO														
Sim-run	Time Interval	Delay Avg (all) (sec/veh)	Stop Avg (All) (S)	Speed Avg (All)	Delay Stop Avg (All)	Dist Tot (All)	Trav Tm Tot (All)	Delay Tot (All)	Stops Tot (All)	Delay Stop Tot (All)	Veh Act (All)	Veh Arr (All)	Delay Lantent	Demand Lantent
3	0-900	187.94	1.10	27.27	150.04	5082.16	670844.45	402758.80	2351.00	321532.28	1103.00	1040.00	22854.70	85.00
3	900-1800	317.83	1.23	12.97	233.94	4594.86	1275678.85	1012926.61	3905.00	745561.99	1758.00	1429.00	178490.10	351.00
3	1800-2700	413.57	1.59	9.05	261.53	3933.82	1564222.35	1338716.95	5156.00	846571.78	1772.00	1465.00	662945.05	1127.00
3	2700-3600	409.07	1.63	9.32	257.00	4082.12	1577254.60	1342562.42	5348.00	843465.77	1720.00	1562.00	1306611.20	1781.00
3	3600-4500	423.85	1.65	8.89	268.37	3882.93	1573108.00	1352076.15	5251.00	856085.16	1764.00	1426.00	1943534.20	2538.00
3	Total	1752.85	7.19	76.80	1171.26	21579.08	6662344.30	5450091.65	22015.00	3613899.53	9883.00	6922.00	4116211.30	8420.00
3	Average	292.14	1.20	12.80	195.21	3596.51	1110390.72	908348.61	3669.00	602316.59	1647.00	1154.00	686035.22	1403.33
3	Standard deviation	168.69	0.63	7.26	104.94	1819.20	646340.08	576263.79	2133.00	358757.47	267.00	593.00	791526.68	1062.01
3	Minimum	0.59	0.00	8.89	0.39	3.19	1236.05	1050.71	4.00	682.55	1103.00	0.00	1776.05	85.00
3	Maximum	423.85	1.65	27.27	268.37	5082.16	1577254.60	1352076.15	5348.00	856085.16	1772.00	1562.00	1943534.20	2538.00

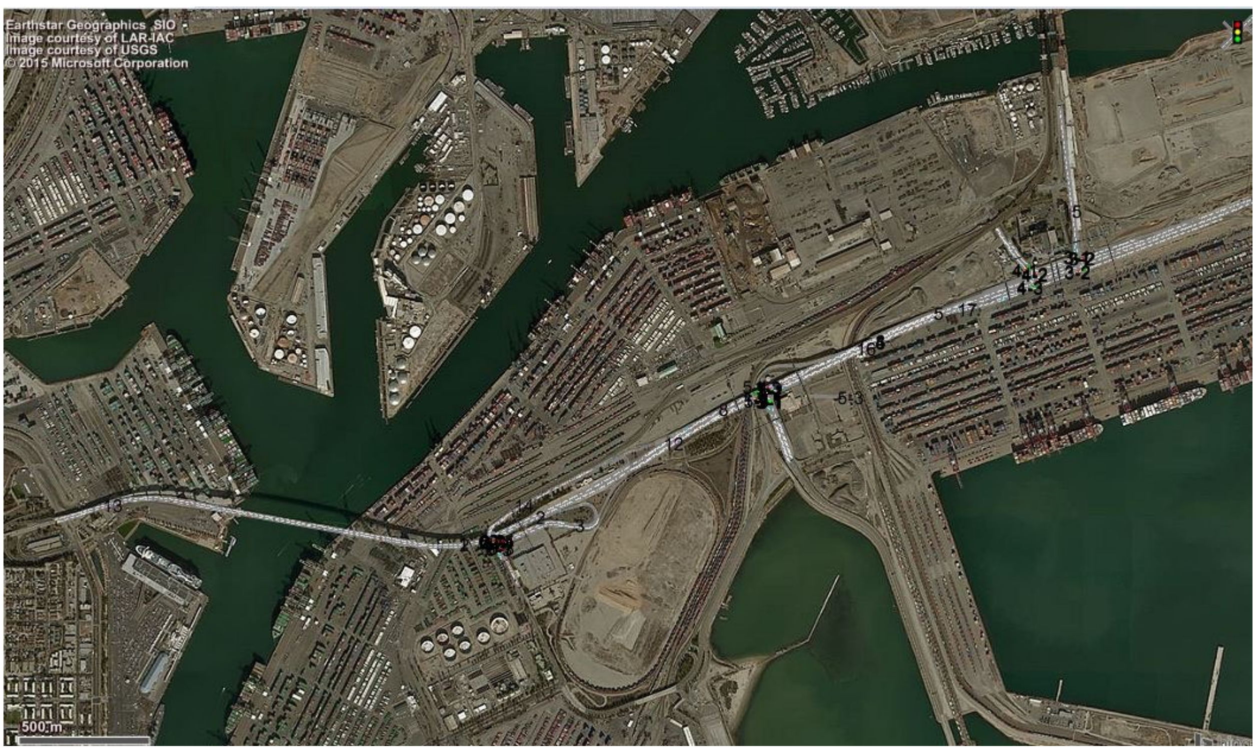

Figure 14: Entire Simulation

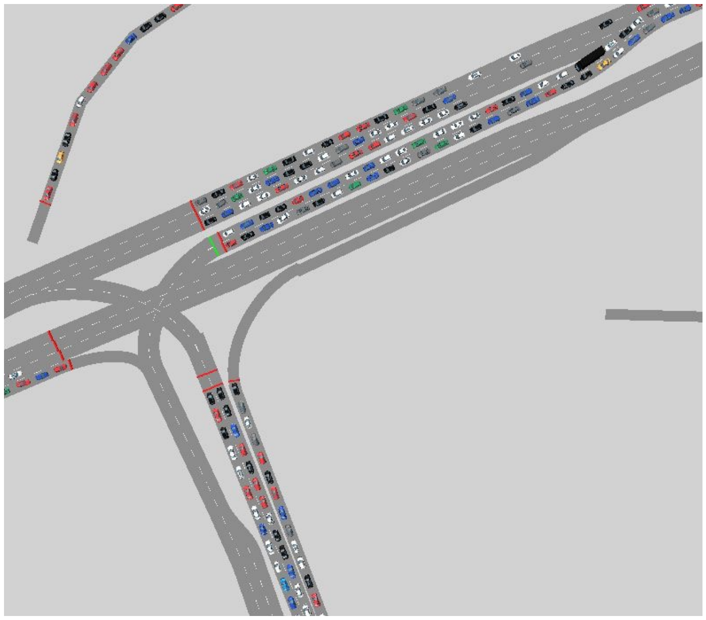

Figure 15: Case Scenario 1

Analysis of this simulation is underway to determine impact on various resiliency measures.

6. **Synthesis of Analyses**

The results of the analyses of the pertinent case studies will be synthesized in developing the tool for port resiliency assessment and planning, including providing appropriate resiliency indices, and will be provided in next year's report. The development is based on available data. The case studies above are based on publically available data. The simulations will be refined, focusing on the three ports and three scenarios that being considered, as more data becomes available. We are working with relevant stakeholders to obtain additional data.

2.2.3. Plans for Transition

These are being developed. Preliminary steps have been taken in terms of engaging stakeholders to determine their needs as discussed in Section 1. The USCG R&D Center will be contacted and we will work with the Research Transition offices at FAU and at Stevens Institute and other stakeholders in developing the appropriate strategy.

2.2.4. Acknowledgements

Fruitful discussions were held with USCG R&D Center and with USCG SECTOR Miami personnel. The authors acknowledge the Gulf Coast Center for Evacuation and Transportation Resiliency; a United States Department of Transportation sponsored University

Transportation Center at Louisiana State University and a member of the University of Arkansas's Maritime Research and Education Center (MarTREC). The authors also recognize the support of Mr. Steve Nerheim of the Houston-Galveston Vessel Traffic Service (VTS) who was instrumental in compiling and explaining the channel closure data used in this study. Continuing discussions with Port Everglades are acknowledged. References and Biography are found in Appendix 1.

3. Education and Outreach

3.1. Overview

MSC has continued to build on the robust portfolio of educational programs that it developed and designed to enhance the technical skills and leadership capabilities of current and prospective maritime and homeland security practitioners. The Center's educational programs leverage the subject matter expertise and research capabilities of its academic partners to provide multidisciplinary hands-on learning opportunities and degree granting programs for a broad audience of students, professionals, stakeholders, and the general public.

During Year 2, MSC offered the following homeland security-focused professional development and college-level educational programs:

- Maritime Incident Discussion-based Tabletop Exercises
- Maritime Systems Seminar Series
- Summer Research Institute
- Maritime Security Master's and Doctoral Fellowship Programs

MSC's educational programs are offered in collaboration with the Center's network of stakeholders. MSC stakeholders include the U.S. Coast Guard (USCG), Customs and Border Protection (CBP), New York Police Department – Counterterrorism Division (NYPD-CTD), National Urban Security Technology Laboratory (NUSTL), Port Authority of New York and New Jersey (PANYNJ), and the New Jersey Office of Homeland Security and Preparedness (NJOHSP), to name a few. These stakeholders have contributed to the Center's educational programs by hosting field-visits, providing feedback on course content and curriculum, input on student research projects, training opportunities, and field-based internships and employment opportunities.

This section of the report provides a summary of the Center's education milestones, followed by a detailed account of the MSC's educational programs and outreach activities during Year 2.

3.2. Summary of Education Milestones

3.2.1. Maritime Incident Discussion-based Tabletop Exercises

In Year 2, MSC in conjunction with SDMI at Louisiana State University developed and delivered an Active Shooter tabletop exercise at the Port of New Orleans. Exercise participants included a broad range of homeland security practitioners, including representation from U.S. Coast Guard Sector New Orleans, U.S. Customs and Border Protection, DHS Homeland Security Protective Services, U.S. Immigration and Customs Enforcement, together with facility security officers from the Carnival and Norwegian Cruise Lines. The Center's efforts included the development and production of exercise materials specific to the Port of New Orleans. However, the Center aims to leverage and modify these exercise materials so that they can be utilized broadly by other Port entities in the future.

SDMI has completed a report detailing participant feedback from the Active Shooter exercise and at the time of this report is preparing the exercise executive summary and lessons learned reports.

MSC and SDMI are also working in conjunction with the U.S. Coast Guard Sector New York AMSC - Cyber Subcommittee to provide exercise support and guidance in the development and delivery of three Cyber discussion-based exercises taking place August 9, 10, and 11, 2016 in the Port of New York/New Jersey.

3.2.2. Maritime Seminar Series

MSC hosted six guest speakers in the Center's Maritime Seminar Series during Year 2. Guest speakers included representatives from industry, government and academia. The range of topics discussed included issues and concerns in Maritime Cybersecurity, Sensor Technologies and Border Security Applications, and Environmental Noise and Acoustic Measurements. MSC seminar participants included representatives from the U.S. Coast Guard, U.S. State Department, Maher Terminals, NYC Emergency Management, New Jersey Office of Homeland Security and Preparedness, Chevron, and ConocoPhillips, together with faculty members, students and administrators from Stevens Institute of Technology and Rutgers University. Seminar feedback and recommendations for future seminar topics was obtained through participant surveys.

3.2.3. 2016 Summer Research Institute

MSC successfully delivered the 7th annual Summer Research Institute, from June 6 to July 29, 2016 on the campus of the Stevens Institute of Technology in Hoboken, NJ. 13 students engaged in the 2016 program, representing seven U.S. universities, including two Minority Serving Institutions. Student demographics included 38% women and 23% minority students. The students engaged in a minimum of six faculty and guest lectures and attended five field-based site-visits and experiments in conjunction with MSC researchers and stakeholders. The SRI student participants were organized into three research teams, each producing a final team report, research posters and final oral presentations. Students demonstrated knowledge gained through weekly status update presentations and in a post-program student survey. Copies of the students' final team presentations can be found on the Center's website at https://www.stevens.edu/research-entrepreneurship/research-centers-labs/maritime-security-center/education-training.

3.2.4. Mechanical Engineering & Homeland Security Doctoral Fellowship

Mr. John Martin was awarded a fully funded Mechanical Engineering & Homeland Security Doctoral Fellowship in August 2015. John was awarded the fellowship following a comprehensive review process conducted by MSC administrators in conjunction with the Mechanical Engineering Department at Stevens Institute of Technology. John completed 18 credits hours of full-time coursework during the 2015/2016 academic year and engaged in research experiments with his dissertation advisor and MSC research PIs. His research interests in robotics and unmanned systems will contribute to the Center's work in Maritime Domain Awareness.

3.2.5. Maritime Security Doctoral Fellowship

Mr. Alex Pollara completed his second year in the Maritime Security Doctoral Fellowship program. Throughout the 2015/2016 academic year, he completed 18 additional credits towards his doctoral degree requirements and successfully passed his PhD oral and written qualification exams.

Alex has contributed to the Center's research in the area of passive acoustic detection systems and helped led the development of a new passive acoustic recording system used in MSC field experiments. His contributions also included representing the Center at a DHS OUP Technology Showcase and his mentorship of a Stevens Senior Design research team in Year 2.

3.2.6. Master's and Doctoral Research Assistantships

MSC supported three students in Master's and Doctoral Research Assistantships at Stevens Institute of Technology and the University of Miami during Year 2. Collectively, the students contributed to MSC's research in Satellite Surveillance Systems, Maritime Cybersecurity and Mobile Maritime Domain Awareness. The students were each enrolled full-time at their respective schools and maintained at least a minimum 3.30 cumulative GPA.

3.2.7. Maritime Systems Master's Degree (CDG) Fellowship Program

In Year 2, two out of the three remaining DHS CDG funded Master's Degree Fellows fulfilled their fellowship and degree requirements to receive Master's degrees in Maritime Systems with a Graduate Certificate in Maritime Security from Stevens Institute of Technology. Both students are now employed in junior engineering positions within the homeland security domain.

The remaining student in the program completed a field-based internship with HSSAI and maintained fulltime enrollment in the Master's degree program.

3.2.8. MSI Outreach and Engagement in Research

MSC put forth efforts to host a DHS MSI Summer Research Team (DHS SRTP) during Year 2. In the fall of 2015, MSC entered into discussions with a faculty member and student research team from New Mexico State University. The team subsequently submitted a joint research proposal to conduct research in the area of passive acoustic underwater threat detection to include electro-optics, in particular underwater light detection and ranging (LIDAR) systems.

The Center made logistical arrangements to host the team, including an established research plan and housing arrangements, only to have the team withdraw their application shortly before the start of the summer research program. Due to the timing of the team's withdrawal from the program, MSC was unable to host an MSI team as planned. The Center therefore was unable to achieve the designated milestones for this project.

3.2.9. USCG Auxiliary Program

The MSC suspended the activities of the Stevens USCG Auxiliary Detachment Unit due in part to the lack of USCG Auxiliary mentorship from Flotilla 21, and the attrition of members from the Stevens program. While the Center was unable to complete the milestones identified in the MSC work plan, MSC administrators have actively pursued alternative Auxiliary support from the Lower Manhattan Flotilla and from the newly established Detachment at John Jay College of Criminal Justice.

The three remaining members in the Stevens Detachment have been invited to attend meetings and training hosted by the Lower Manhattan Flotilla.

The remaining section of the education annual report includes details regarding each of the programs summarized above.

3.3. Professional Development Programs

3.3.1. Maritime Incident Discussion-based Tabletop Exercises

Milestone	Performance Metric	Status / Discussion
1. Development of scenario driven tabletop exercise	MSC academic partners (Stevens/LSU/MIT and designated stakeholders) will plan a minimum of four (virtual and/or face-to-face) meetings to discuss port location(s), scenario themes, and objectives for a tabletop exercise. -A summary of the scenario planning process and port location details will be chronicled in meeting summary reports. -LSU/SDMI will identify and confirm a port partner in the New Orleans region to engage in and host the tabletop exercise. -LSU/SDMI will prepare a draft exercise manual for review and input by MSC partners. -A date will be confirmed for the exercise, participants will be identified and a final exercise manual will be prepared.	**Completed** – A scenario and all other corresponding milestones in this section were met and completed during Year 1.
2. Delivery of MSC sponsored discussion-based TTX	A minimum of one tabletop exercise will be delivered during Year 2. -LSU/SDMI will facilitate and deliver the exercise in conjunction with MSC partners. -Exercise participants will receive certificates or PDUs for their participation.	Completed - MSC/LSU held an Active Shooter TTX at the Port of New Orleans on June 8, 2016. In process: Certificates of participation are being prepared for the host organization and the TTX participants.

3. Exercise reports prepared	-An assessment of the exercise will be gathered from participant surveys and exercise evaluator notes. -A report will be prepared for the host organization to include a matrix of the core capabilities assessed, the reported and observed strengths and weaknesses in meeting the core capabilities, and recommendations for improvements. -MSC will prepare a second report detailing lessons learned in the planning and delivery phases of the exercise to be used for future tabletop exercises and/or the development of a port focused “Exercise in a Box” kit.	Completed: Participant surveys and exercise evaluator notes were completed and assessed. In process: The completion of these performance metrics were delayed by one month due to MSC/LSUs engagement and facilitation of the Sector New York Area Maritime Security Committee’s Maritime Cybersecurity tabletop exercises.

The MSC has expanded its professional development programs to include the development and implementation of preparedness and response discussion-based exercises for port and terminal operators. Through this effort, MSC in conjunction with its academic partners from the Stephenson Disaster Management Institute (SDMI) from Louisiana State University (LSU), set out to build upon other nationally recognized emergency response executive education programs to provide support and resource materials for maritime and port stakeholders.

One of the primary purposes of this project is to develop the tools to assist port facilities and terminal operators across the country in developing their own high-level discussion based exercises. The first two years have allowed MSC and SDMI to identify gaps in existing scenarios and to begin the development of an exercise resource portal in Year 3.

Figure 1. Brant Mitchell, MSC research PI (center), sets the stage for the Center's active shooter TTX at the Port of New Orleans.

During the initial planning phase of the project in Year 1, MSC and SDMI met routinely with stakeholders from the U.S. Coast Guard – Sector New York and Sector New Orleans, the New Jersey Office of Homeland Security and Preparedness (NJOHSP), and the Port of New Orleans to ascertain the threat scenarios that were most concerning to them. Through this engagement, the two most prominent hypothetical scenarios identified by the stakeholders involved an active shooter event within a port terminal and a cyber-attack that adversely impacted port operations.

In Year 2, SDMI developed an active shooter scenario and all of the components needed to host and deliver the discussion-based exercise. These components included:

- Scenario content pertaining to an active shooter event during the embarkation and disembarkation of cruise terminal within the Port of New Orleans,
- Tailored active shooter video injects to simulate media and news coverage during such an event,
- A series of exercise discussion questions intended to exercise key emergency response core capabilities, including Information Sharing, Operational Coordination and Post-incident Economic Recovery,
- A sequence of tailored modules designed to progressively tease out discussion on each of the core capabilities,
- Exercise support materials including presentation slides, exercise guides, scenario descriptions and module prompts, and
- A post-exercise participant feedback form and survey.

Materials developed for the Active Shooter exercise were initially tailored to the Port of New Orleans, however, the Center intends to modify the exercise and make it available for use by other port and terminal operators regardless of their geographical location.

On June 8, 2016, SDMI successfully delivered the active shooter discussion-based tabletop exercise (TTX) at the Port of New Orleans. The TTX included the participation of over 20 Federal, State and local agencies, including DHS representatives from the U.S.

Coast Guard Sector New Orleans and Sector New York (USCG), U.S. Customs and Border Protection (CBP), DHS Homeland Security Protective Services, U.S. Immigration and Customs Enforcement (ICE), together with facility security officers from the Carnival and Norwegian Cruise Lines. Overall there were 56 people in attendance.

The exercise included nationally renowned facilitators and subject matter experts in active shooter operations, economic impact and port emergency operations, including representation from the DHS COE - National Consortium for the Study of Terrorism and Responses to Terrorism (START). Serving as a subject matter expert, Steve Sin, a Senior Researcher at START, provided a terrorism threat overview to ensure that the exercise participants had a general understanding of current and emerging threat vectors in the maritime domain.

Initial results from the participation feedback form included the following responses on a scale of 1 to 5, with 5 indicating the highest level of agreement to the question:

- Exercise scenario was plausible and realistic – 4.37
- Exercise participants included the right people – 4.62
- Participants were actively involved in the exercise – 4.48
- Exercise participation was appropriate from someone in my field – 4.42
- Exercise increased my understanding and familiarity with the capability and resources of other participating organizations – 4.3
- Exercise provided the opportunity to address significant decisions in support of critical mission areas – 4.14
- After this exercise, I am better prepared to deal with the capabilities and hazards addressed – 4.0

Following the delivery of the active shooter TTX, SDMI completed a summary of the exercise participant survey.

During this time, MSC and SDMI were afforded the opportunity to provide support for the development of three Maritime Cybersecurity tabletop exercises to be held August 9, 10 and 11, 2016. The exercises were held in collaboration with the Sector New York Area Maritime Security Committee (AMSC) – Cyber Subcommittee, in which MSC's Director of Education serves as a co-chair and Brant Mitchell, SDMI Executive Director serves as a subcommittee member.

As a result of the Center's efforts to support the Sector New York AMSC tabletop exercises, the completion of the Port of New Orleans Active Shooter summary report and the exercise lessons learned report were delayed by one month.

3.3.2. Maritime Systems Seminar Series

Milestone	Performance Metrics	Status/Discussion
Delivery of maritime systems/homeland security focused seminars. Year 1 – 1/1/15 – 6/30/15. Year 2 – 7/1/15 – 6/30/16.	-MSC will host four seminars during Year 1 and six seminars during Year 2. -A survey will be used to assess the quality of the presentation, the relevance of the topic and to gather feedback for future seminars. -Webinars/Seminars will be made available to the public. (e.g., presentation slides will be posted on the MSC website and podcast recordings will be available on Stevens iTunes U account.). -Speakers will include MSC researchers and guest speakers from the homeland security domain.	The Center hosted five invited guest seminars during Year 2. A sixth seminar was scheduled to be held in March 2016, however, the invited speaker postponed his talk on the Linux Foundation's Core Infrastructure Initiative to a future date TBD. Completed: A survey was created and utilized to assess seminars and to gather feedback for future talks (see appendix). Completed: When approved by the speaker, seminar talks were recorded and slides were made available online (link provided below).

MSC with the support of other departments at Stevens Institute of Technology co-hosted several guest speakers in the Maritime Systems Seminar Series. The Year 2 seminar series included lectures by MSC and affiliate researchers, and leading experts and practitioners in homeland security. The seminar series is designed to engage a broad audience of faculty, students, industry and government stakeholders, and the general public in relevant and timely topics in the maritime and homeland security domain. Some of this year's seminar participants included representatives from the U.S. Coast Guard, Maher Terminals, NYC Emergency Management, New Jersey Office of Homeland Security and Preparedness, the U.S. State Department, Chevron, and ConocoPhillips, together with faculty members, students and administrators from Stevens Institute of Technology and Rutgers University.

The seminar series is delivered on-campus at Stevens Institute. When possible, the presentations were recorded and made available on the Seminar Series webpage at: http://www.stevens.edu/ses/maritime-systems-seminar-series. Feedback from the seminars was gathered in the form of a survey distributed to participants who physically attended the seminar. The intent of the survey was to gather information regarding attendee demographics (e.g. student, faculty, or industry guest), reasons for attending (e.g. topic was relevant to the participant's job/academic program, personal development, etc.), feedback on the quality of the seminar (e.g. did it meet the participant's expectations), and recommendations for future topics.

Completed surveys demonstrated that the majority of participants attended the seminars from the Stevens community of faculty, staff and students, and that the seminars were attended out of personal interest and relevance to the attendee's job/academic program. Suggestions for future MSC seminars included additional topics in Cybersecurity threats, GPS spoofing and AIS fraud detection. Going forward MSC aims invited guest speakers to discuss these topics. A copy of the seminar survey can be found in Appendix 2.

The seminars delivered during Year 2 are outlined in Table 1 below.

Table 1. Maritime Systems Seminar Series

Faculty/Guest Lecturer	Seminar	Date
Frank Vesce, Goldman Sachs	*Core Practices and Processes in Cybersecurity*	06.30.2016
Frank Hooten, Texas Military Department	*Topic 1: AMU – Maritime Cybersecurity Research* *Topic 2: The Use of Sensor Technologies in Border Security*	06.17.2016
Jeffrey Milstein, Moran Shipping	*Maritime Stakeholders and the Role of the Port Agent in Maritime Operations*	06.12.2016
Michael Cole, NYPD-Information Technology Bureau	*Cyber is Computers*	02.10.2016
Kate Belmont, Blank Rome LLC	*Maritime Cybersecurity: Anticipating, preventing and mitigating a growing threat.*	12.10.2015

In addition to contributing to the Center's Seminar Series, several of the guest speakers have contributed to other aspects of the Center's research and educational program curriculum.

3.4. College-level experiential learning and research-based programs

3.4.1. The 2016 Summer Research Institute

Milestones	Performance Metrics	Status/Discussion
1. Featured lectures by MSC researchers and invited guests. (Weeks One – Eight) (6/6/16 – 7/29/16)	-A minimum of two homeland security/maritime industry guest speakers will be hosted during the summer research program. -A minimum of six faculty lectures will be provided during the eight-week program. -The quality of and knowledge learned from the lectures will be assessed through a post- program student survey.	Completed: Three guest speakers were hosted during the 2016 SRI. Eight faculty lectures were held during the first week of the SRI, with additional lectures held throughout the program. A post-program survey was completed by all 13 participants.
2. Field-visits and field-based activities. (Weeks One – Seven) (6/6/16 – 7/22/16)	-SRI students will engage in a minimum of two field-visits per summer research program. -MSC will facilitate a minimum of one field-based activity (meeting with stakeholders, research experiments/deployments, attendance at a workshop) during the program. -The impacts of the field-visits and field-based activities on student professional development and networking skills will be assessed through a post-program student survey.	Completed: A minimum of two field-visits were completed this summer. (CBP and NYPD-CTD). Students participated in a minimum of two field-based experiments, one training session (NYPD-CTD), a tabletop exercise (NJ OHSP). A post-program survey was conducted and completed by all 13 participants.
3. Diversity of student participants. (6/6/16 – 7/29/16)	-Diversity will be measured according to the range of engineering and science majors represented in the program. A minimum of four different disciplines will be represented per SRI program. - Student diversity will be measured by the percentage of women and minority students participating in the program each summer. A diverse student population will include a minimum of 50% women and/or minority students.	Completed: Student demographics included 53% women and minority students. Student academic disciplines included 8 unique majors.

4. Research Reports, Presentations and Posters. (Week Eight) (7/25/16 – 7/29/16)	-A minimum of two student research team reports will be prepared at the end of each SRI program. -A minimum of two student research team posters will be prepared at the end of each SRI program. -Students will engage in weekly status update presentations during weeks three – seven. -Stakeholder engagement will be assessed by representation of MSC stakeholders attending the final student team presentations. -Quality of SRI research outcomes will be assessed by MSC research mentor feedback and the number of projects selected for presentation at conferences (e.g. DHS OUP University Summit) and/or for publication. -Program impacts, e.g., professional development, technical skills learned, teamwork, and student interest in advanced academic study or careers in homeland security will be assessed by a post-program student survey.	Completed: Two out of the three student research teams prepared reports approved by their faculty mentors. The teams also prepared final presentation slides and research posters. Completed: A minimum of two final reports were prepared and approved by their faculty mentors. A post-program survey reported that students significantly improved their skills in their ability to conduct research, oral presentations, professional confidence and teamwork /collaboration. 90% of the students reported that the SRI enhanced their interest in advanced academic study and careers in HS.
5. Post-Program and SRI alumni survey. Post-program surveys to be conducted (Week Eight) (7/25/16 – 7/29/16)	-A minimum of one student survey will be conducted at the end of each summer research program. The survey will be used to measure the strengths and weakness of the program, the program's impacts on student interest and skills development, and to gather feedback to enhance the future delivery of the program.	Completed: A post-program survey was completed by the program participants and assessed by the MSC.

MSC held its 7th Annual Summer Research Institute (SRI), from June 6 – July 29, 2016, at the Stevens Institute of Technology campus in Hoboken, NJ. Since the Summer Research Institute's inception in 2010, 116 students have conducted research in conjunction with MSC research PIs, stakeholders and Stevens' faculty members. Each year, the Center identifies a set of student research projects that coincide with the Center's ongoing and emerging areas of research. The SRI student research projects are purposely designed to expose students to critical issues in the maritime domain and to challenge them to find innovative and technological approaches to address them. .

MARITIME SECURITY CENTER

MSC SUMMER RESEARCH INSTITUTE

Student Benefits
- Enhanced educational experience through experiential learning and research.
- Engagement in research and analysis as it relates to US maritime and port security.
- Competitive summer research stipends and on-campus accommodations.

Criteria for Participation
- Undergraduate students must possess an excellent academic record (GPA of 3.0 or better) and currently enrolled in a degree program.
- Graduate-level students must be currently enrolled in a degree program and demonstrate a GPA of 3.5 or better.
- Students from MSC partner schools are given priority in admissions decisions.

Application Process and Deadline
Students must submit a statement of interest, one letter of recommendation, and complete an online application form on the MSC website www.stevens.edu/ses/msc/education/summer-research-institute/apply. The deadline for submitting applications is February 26, 2016.

Location
The MSC Summer Research Institute is held on the Stevens Institute of Technology campus in Hoboken, NJ. Situated along the Hudson River, opposite the New York City skyline, the Stevens campus provides Summer Institute students a unique opportunity to study first-hand the complex maritime security issues of urban waterways and ports.

For more information, please contact
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Maritime Security Center (MSC)

SUMMER RESEARCH INSTITUTE 2016

June 6 - July 29, 2016
Hoboken, New Jersey

www.stevens.edu/ses/msc

STEVENS

Figure 2. SRI 2016 Program Brochure

The Center continues to track the academic and professional activities of its summer research students, and has cultivated an active and engaged alumni network via email correspondence and a designated MSC SRI Alumni LinkedIn group.

In 2016, the MSC hosted 13 student participants representing the following seven universities: Stevens Institute of Technology, University of Puerto Rico-Mayaguez (UPRM), University of Alaska – Anchorage (UAA), University of Alaska – Fairbanks (UAF), American Military University (AMU), Capitol Technology University, and Texas Southern University (TSU). 84% of the student participants were undergraduate engineering and science majors and 12% included graduate-level students. Additional student demographics included 38% women and 23% student representation from minority serving institutions and minority communities.

To support student participation in the 2016 summer research program (e.g., housing, stipend and travel), the Center leveraged existing Stevens Institute of Technology scholarship programs and those of its academic partners to recruit students who could attend the summer research program fully-funded through external funding sources. Out of the 13 program participants, seven students attended the program leveraging funding from Stevens Institute of Technology's Scholars Program, the Arctic Domain Awareness Center (ADAC), and from personal resources.

This summer, MSC in partnership with ADAC created two summer research opportunities for University of Alaska students. ADAC's contributions included funding support for one UAF Mechanical Engineering undergraduate student and one UAA Civil Engineering undergraduate student. Out of the remaining externally funded students, one student personally financed their participation and six were supported through the Stevens Institute of Technology Scholars Program, a competitive, invitation-only program for high-achieving undergraduate STEM students.

Funding for the remaining five students was provided by MSC. The MSC funded-students were selected through the Center's academic partnerships and through a competitive admission process. The students admitted into the program were endorsed by their academic professors, expressed interest in homeland security research and concerns, and met the Center's admission criteria. Figure 3 below shows a picture of the 2016 SRI participants and Table 2 identifies the participants and the funding sources leveraged to support their participation.

Figure 3. SRI 2016 students gather for a group photo following a Port Awareness and Response Training hosted by the New York Police Department.

Table 2. SRI 2016 Student Participants

University	Student Participant	Academic Major & Degree Status	Funding Source
American Military University	Katrina Jacobson	Cybersecurity/Undergrad.	MSC
Capitol Technology University	Dania Allgood	Cybersecurity/Undergrad.	MSC

Stevens Institute of Technology	Eric Baskayan Anthony Bianco Shicong Hao Shir Pilosof Laurie Prinz Ahsan Shahab Luciano Triolo	Electrical Eng./ Undergrad. Eng. Undecided/Undergrad. Ocean Eng./Grad. Mechanical Eng./Undergrad. Civil Eng./Undergrad. Computer Eng./ Undergrad Mechanical Eng./Maritime Systems (Undergrad/Grad)	Stevens Scholar Stevens Scholar Self-supported Stevens Scholar Stevens Scholar Stevens Scholar MSC
Texas Southern University	Samuel Tefeera	Computer Science/Under-grad.	MSC
Univ. of Alaska – Anchorage	Christina Hoy	Civil Eng./Undergrad.	ADAC
Univ. of Alaska – Fairbanks	Alvaro Murillo	Mechanical Eng./ Under-grad.	ADAC
Univ. of Puerto Rico -Mayaguez	Raul Huertas	Electrical Eng./Grad	MSC

3.4.2. Student Qualifications and Documentation

Participation in the Summer Research Institute requires that students be actively enrolled in an undergraduate or graduate-level degree program at an accredited university. Undergraduate students must possess a minimum GPA of 3.0, and graduate-level (Master's and PhD) students are required to have a GPA of 3.5 or better. This past summer's participants were required to complete an online application form, write a personal statement of interest and submit transcripts and letters of recommendation upon request. In accordance with Stevens policy, visiting SRI students were also required to demonstrate proof of health insurance and submit immunization records to Stevens Health Center prior to attending the program.

3.4.3. SRI Summer Research Stipends and Housing

Students in the 2016 SRI received summer stipends up to $4,000 and were provided accommodations on campus in the Stevens dormitory housing. Travel reimbursements up to $1,000 were also made available for transportation to and from the start and end of the program for students residing outside of New Jersey.

3.4.4. SRI Program Administration

The 7th annual SRI continued to be organized and coordinated by MSC Director of Education, Beth Austin-DeFares, in conjunction with Dr. Barry Bunin (Director, Stevens Institute of Technology Maritime Security Program). Ms. Austin-DeFares serves as the primary program facilitator, while Dr. Bunin participates as the lead faculty facilitator and curriculum developer. SRI student team mentorship was provided by MSC research PIs and Stevens faculty including Dr. Alexander Sutin (Research Professor, Acoustics), Dr. Yegor Sinelnikov (Research Engineer, Acoustics), Dr. Dimitrios Damopoulos (Teaching Assistant Professor, Cybersecurity) and by Stevens Master's and Doctoral students Blaise Linn (Maritime Systems Graduate Research Assistant), Alex Pollara (Maritime Security Doctoral Fellow) and Hasan Shahid (Maritime Systems Master's Degree Fellow).

3.4.5. SRI Program Format and Curriculum

WEEK ONE	JUNE 6 (Monday)	JUNE 7 (Tuesday)	JUNE 8 (Wednesday)	JUNE 9 (Thursday)	JUNE 10 (Friday)
9 am – 1pm	9:30am Welcome & Housekeeping – B. DeFares 9:45am Student Introductions 10:15 am Faculty Introductions 10:45am Break 11:00am Project Overviews – Discussion of Projects (5 mins. each) Y. Sinelnikov – Environmental Acoustics B. Linn – Buoy Noise D. Damopoulos - Maritime Cyber Security 12:00pm Student Team Assignments	9:00am Intro to Marine Transportation System (MTS) Expansion of Global Trade since WWII – T. Wakeman	9:00am Development of Containers & Intermodalism Intro to Safety & Security in Ports – T. Wakeman	9:00am Observations Report-out and Discussion – T. Wakeman 11am Oceanography & Estuaries – T. Wakeman	9:00am Port Competition Presentations - Faculty
12:00	Group Lunch	Lunch	Lunch	Lunch	Lunch
2:00pm – 5pm	2pm MSL Lab Overview: A. Pollara / B. Linn 2:30pm - Photo IDs for non-Stevens Students 3pm Student Activity TBD	2pm History of Ships, Harbors/Ports, and Cargo Terminals – T. Wakeman	1pm Observations, Analysis and Threat Assessments Field Visit – to Staten Island Ferry via Hoboken Ferry	Maritime Business "It's about the money!" – T. Wakeman	Student Free Time to Explore Hoboken and NYC

Figure 4. Schedule for Week One of the 2016 SRI.

The eight-week program includes a balance of in-class lectures, student team research projects, professional development activities, and field-based learning opportunities. Orientation to the 2016 SRI was conducted during the first week (June 6 – 10) of the program. In past years, the SRI orientation was held over a two week period, however, lessons learned throughout the seven years of the program delivery have led MSC administrators to adjust the SRI program format to limit class room lectures to provide for more time for the students to engage in their research.

Dr. Thomas Wakeman, Director Maritime Systems Program at Stevens, provided a series of introductory lectures tailored to immerse students in a comprehensive overview of the Maritime Transportation System (MTS), maritime policy, maritime stakeholders, and port facility infrastructure and operations. During the program orientation, students were also assigned to one of three faculty-mentored projects. This summer's research projects included:

- Maritime Cybersecurity Threats and Vulnerabilities

- Environmental and Urban Noise Acoustics
- Buoy Noise – Impacts on Underwater Detection Systems

The student teams were organized according to student skills and expressed research areas of interest. Starting Week Two, the program format shifted from time spent in the classroom to time spent engaging in team research projects, field-based visits and experiments, and meetings with maritime practitioners. During the next five-week period, student teams also began to provide status updates on their research in the form of weekly presentations and Power Point slides. Each team was responsible for providing a fifteen to twenty minute presentation describing their research, their field-based activities and engagements, any challenges they encountered, and the progress they were making. Throughout Weeks Two through Seven, the students also attended lectures by guest speakers, conducted experiments at the U.S. Merchant Marine Academy and in the Madison Square Garden/Penn Plaza area and engaged in field-visits to CBP at Port New York/Newark, NYPD, and others. Details regarding guest speakers and field-visits are provided later in this report.

In Week Seven, the student teams began to synthesize their research and started to compile their final team research reports with the support of their faculty mentors. In Week Eight, the last week of the summer research program, students submitted their final reports and provided team presentations to an audience of MSC research PIs, Stevens' faculty members and invited guests.

Tables 3 and 4 below illustrate the program activities and guest speakers for each week of the 2016 SRI. SRI students are frequently encouraged to ask questions and take advantage of the opportunity to engage practitioners and experts in a dialog as it pertains to their respective research projects and general academic and career interests.

Table 3. SRI 2016 Program Activities Weeks One to Eight

Schedule	Topic	Faculty /Guest Speakers	SRI 2016 Activities
WEEK ONE June 6 – 10	MDA/MTS Industry Overview	Dr. Thomas Wakeman – Maritime Domain Orientation	Introductions and team assignments. Security and vulnerabilities observations - field visits to ferry terminals. Cybersecurity team meeting with USMMA Cyber Student Defense Team.

WEEK TWO June 13 - 17	Team Research Assignments and Projects	- Jeffrey Milstein, Director of Operations, Moran Shipping and Sector NY AMSC Chair -Frank Hooten, Texas Military Department	CBP Field-visit – Port of New York/Newark. COMSOL Multiphysics® Software Training.
WEEK THREE June 20 - 24	Team Research Projects		Technology deployment and experiment at USMMA in Kings Point, NY. Port Awareness and Response Training – NYPD CTD. Status Update Presentations.
WEEK FOUR June 27 – July 1	Team Research Projects	-Frank Vesce, Goldman Sachs and Sector NY AMSC Cybersecurity Committee member -Dr. MG Prasad – Topics in Environmental Acoustics and Urban Noise	Field-experiment – Madison Square Garden/Penn Plaza NYC. Status Update Presentations.
WEEK FIVE July 4 – July 8 (Note that activities after June 1 for the SRI are considered planned activities but are reported here for consistence)	Team Research Projects		Experiment – Stevens Anechoic Chamber.
WEEK SIX July 11 – 15	Team Research Projects		SONIC Sea – Film Screening. Technology Deployment and Experiment – Hudson River Status Update Presentations.
WEEK SEVEN July 18 - 22	Research Synthesis		Final report writing.

WEEK EIGHT July 25 - 29	Team Reports	MSC research PIs Stevens Faculty	Final Research Team Presentations.

Table 4. SRI 2016 Guest Speakers		
Guest Speaker	**Organization**	**Lecture Topic**
Jeff Milstein	Moran Shipping	Role of the Port Agent in the MTS.
MG Prasad	Stevens Institute of Technology	Environmental and Urban Noise Measurements.
Frank Hooten	Texas Military Department	Sensor Technologies and Border Security and AMU Maritime Cybersecurity Research
Frank Vesce	Goldman Sachs	Core Practices and Processes for Cybersecurity.

3.4.6. SRI Field Visits and Meetings with Practitioners

Field visits to ports and homeland security operational locations are an important aspect of the Summer Research Institute. Field visits provide a unique opportunity for students to observe the operational activities and responsibilities of homeland security professionals in the field (see Figure 5 below).

Figure 5. CBP Officer Moloney hosts SRI 2016 students for a field visit and hands-on review of the agency's Non-Intrusive Inspection (NII) equipment used to scan cargo at the Port of New York/Newark.

During the 2016 SRI, students participated in field visits and engaged in activities with representatives from the following homeland security organizations:

- Customs and Border Protection (CBP) Tactical Operations Division – Field visit
- U.S. Merchant Marine Academy (USMMA) – Field visit and Experiment
- New York Police Department – Port Awareness and Response Training
- New Jersey Office of Homeland Security and Preparedness – Transportation and Commerce Security Tabletop Exercise

Over the past five years, CBP has hosted the Center's summer research students for a complete tour of the agency's facilities at the Port of New York/Newark. On June 16, 2016, CBP welcomed the latest cohort of SRI students and faculty mentors for a presentation highlighting the agency's mission areas and a tour of the organization's Tactical Operations Division. Coordinated by CBP Officer Noel Moloney, the visit included first-hand observations of radiation portal monitors in use, high-energy mobile non-intrusive inspection (NII) equipment scanning cargo containers, and a tour of a Centralized Examination Station warehouse where cargo is physically inspected and analyzed, and CBP agricultural specialists examine products for pests and invasive species.

The engagement of SRI students in field visits and networking events with homeland security practitioners have resulted in invitations for students to attend other local and regional homeland security activities, including tabletop and full-scale exercises, law enforcement and emergency response technology demonstrations, and local Area Maritime Security Committee (AMSC) meetings.

A recent example involves an invitation by the NJ Office of Homeland Security and Preparedness (NJOHSP) for the SRI students to serve as evaluators for a Transportation and Commerce Security Tabletop Exercise (TTX) held on May 25, 2016, a week prior to the start of the SRI. The discussion-based TTX was designed to fulfill the requirements of the USCG CFR105 – Facility Security Regulations for Terminal Operators. Exercise participants included facility security officers (FSOs) and representatives from Maher Terminals, APM Terminals, Port Newark Container Terminal, Global Container Terminals, Global New York, together with representatives from the Port Authority of New York/New Jersey, NY Shipping Association, and the USCG Sector New York. The intent of the TTX was to demonstrate the ability of terminal operators to communicate, coordinate and continue operations while responding to a security incident.

The SRI student participants were each assigned a terminal operator to evaluate and were responsible for completing observation notes and ratings as to the terminal operator's ability to meet stated core capabilities and critical tasks in the areas of operational coordination, situation awareness and operational communications. Following the exercise, the students compiled their observations and submitted the required rating sheets to the NJ OHSP for their review and processing. The reports were later distributed to the respective terminal operators for their after-action response.

3.4.7. SRI 2016 Student Research Projects

In planning for the SRI 2016 program, MSC administrators assessed the Center's current and emerging research projects and determined three specific projects to be the most advantageous the Center and to the experiential learning of the summer research students. The projects and student team assignments are described below.

Maritime Cybersecurity Threats and Vulnerabilities Team

During the 2016 summer research program, the Center organized a team of Cybersecurity and Computer Science undergraduate students (see Figure 6 below) to better understand the attributes of the maritime cyber system that make it unique and set it apart from other critical infrastructure sectors(e.g. Energy, Financial Services, Food and Agriculture, etc.). The team was challenged to create an overarching diagram of the stakeholders and entities that comprise the Port of New York and New Jersey maritime community and to assess Cybersecurity vulnerabilities from both a port side and shipboard perspectives.

In addition to a network drawing that delineates the maritime cyber domain from the physical domain, students conducted risk assessments based on cyber threat scenarios involving maritime shipping agents, port facility operations (industrial control systems), and shipboard systems (Electronic Chart Display and Information System and GPS).

Throughout the eight-week summer research program, the students had the unique opportunity to discuss maritime Cybersecurity concerns and practices with representatives from Moran Shipping, Goldman Sachs, American Military University Maritime Cyber research team and the USMMA Cyber Defense student team. The students were also able to observe first-hand port facility operations at the Port of New York/Newark.

Outcomes from the team's research included a research report outline and a presentation to MSC stakeholders, Stevens' faculty members and invited homeland security guests.

Figure 6. Dania Allgood, Katrina Jacobson and Samuel Teferra (left to right) review network diagrams with their faculty mentor Dr. Damopoulos (near right).

Table 5. Maritime Cybersecurity Threats and Vulnerabilities Team

Student	Academic Discipline	School
Dania Allgood	Cybersecurity	Capitol Technology University
Katrina Jacobson	Cybersecurity	American Military University
Samuel Tefeera	Computer Science	Texas Southern University
Faculty Mentor: Dr. Dimitrios Damopoulos, Teaching Assistant Professor		

Environmental Acoustics and Urban Noise Team

Figure 7: Students on the Environmental Acoustics Team prepare to take noise measurements of vessel traffic at the U.S. Merchant Marine Academy, adjacent to the Long Island Sound.

Environmental acoustics includes the measurement and analysis of noise and vibration in the environment and enables mediation and mitigation of all types of environmental noise sources, ranging from transportation and industrial sources to outdoor entertainment facilities.

The Environmental Acoustics and Urban Noise team learned the basis of environmental acoustics and the measurement of acoustic noise in various urban areas and at different times. The students worked to advance the current level of research conducted in noise measurements and to include the measurements of a full-spectra of urban noise, paying particular attention to noise features that can be used for classification of sources of sound.

Identification of the characteristic of discrete sound sources in a boisterous environment has substantial applications for maritime and homeland security applications. Having the capabilities to filter out known sound events enhances the likelihood of the acoustic detection and identification of a potentially unlawful intruder or anomalies to a soundscape.

Throughout the summer research program, the Environmental Acoustics Team conducted air acoustic environment measurements at the USMMA in Kings Point, NY and at Madison Square Garden/ Penn Plaza Pavilion in New York City, using a linear alignment of calibrated microphones. Characteristic sounds were identified in the data collected and their unique acoustic signatures were measured using Stevens Institute of Technology's Anechoic Chamber.

The implications of understanding discrete sound identification and the development of algorithms to isolate a single sound source within a number of noise sources, such as identifying a bird chirp during rush hour at Penn Plaza in New York City, can be leveraged for homeland security applications and the detection of threats.

The team utilized Stevens Institute of Technology developed signal processing programs to process their data and were able to visualize their recordings using COMSOL Multiphysics® software.

Outcomes from the team's research included a research report and a presentation to MSC research PIs, Stevens' faculty and invited homeland security guests. Table 6 below includes a list of the students and faculty mentors for the Environmental Acoustics Team. Details regarding the team's project outcomes can be found in their final presentation slides located on the MSC SRI website at: https://www.stevens.edu/research-entrepreneurship/research-centers-labs/maritime-security-center/education-training/summer-research-institute/sri-2016

Table 6. Environmental Acoustics and Urban Noise Team Members

Student	Academic Discipline	School
Anthony Bianco	Engineering Undecided	Stevens Institute of Technology
Raul Huertas	Electrical Engineering	Univ. of Puerto Rico - Mayaguez
Alvaro Murillo	Mechanical Engineering	Univ. of Alaska - Fairbanks
Laurie Prinz	Civil Engineering	Stevens Institute of Technology
Faculty Mentors: Dr. Yegor Sinelnikov, Research Engineer and Dr. Barry Bunin		

Buoy Noise – Effects on Underwater Detection Systems Team

The Buoy Noise Team conducted research to profile environmental noise to determine its impacts on underwater passive acoustic systems used for vessel detection and security purposes.

In conducting their work, the student team members deployed passive acoustic recording systems adjacent to ATON buoys, in areas of interest in the Long Island Sound and in the New York Harbor. Students also gathered data from other sensors at the MSC Maritime Security Laboratory including radar, electro-optic/infrared (IR) cameras, and Automatic Information Systems to provide ground truth information for the acoustic analysis.

Out of the two field-based deployments and experiments, only one set of recordings produced tangible acoustic readings and data. In the first experiment, the recording system failed to record. As a result, the student team had to reassess the system and determine the points of failure and why the system did not perform as intended. Their analysis determined that the connections made inside the box failed and needed to be more ruggedized for such an application, which led them to modify the system and develop a back-up secondary recording platform.

Upon their second field-based deployment in the New York Harbor, the team was able to record baseline data on the inherent noise made by buoys that they produce in harbor environments. The team utilized Laboratory Virtual Instrument Engineering Workbench (LabVIEW) to analyze and present the recorded data.

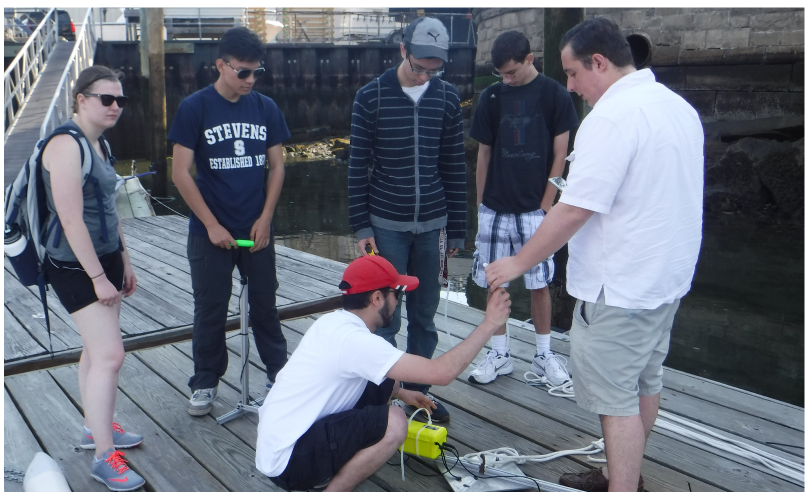

Figure 8: Students on the Buoy Noise Team prepare a passive acoustic recording system for deployment and experiments at the U.S. Merchant Marine Academy.

Outcomes from the team's research included a research report and a presentation to MSC research PIs, Stevens' faculty members and invited homeland security guests. Details regarding the Team's project outcomes can be found in their final research report and presentation slides located on the MSC Summer Research Institute website at: https://www.stevens.edu/research-entrepreneurship/research-centers-labs/maritime-security-center/education-training/summer-research-institute/sri-2016

Table 7 below includes a list of the students and faculty mentors for the Buoy Noise summer research team.

Table 7. Buoy Noise Team Members

Student	Academic Major	School
Eric Baskayan	Electrical Engineering	Stevens Institute of Technology
Shicong Hao	Ocean Engineering	Stevens Institute of Technology
Christina Hoy	Civil Engineering	Univ. of Alaska – Anchorage
Shir Pilosof	Mechanical Engineering	Stevens Institute of Technology
Ahsan Shahab	Computer Engineering	Stevens Institute of Technology
Luciano Triolo	Mechanical Engineering	Stevens Institute of Technology
Faculty Mentors: Blaise Linn and Hasan Shahid		

3.4.8. SRI 2016 Student Survey

An assessment of the 7th annual summer research program was conducted via a post-program student survey (see Appendix 3 for a copy of the SRI 2016 student survey questions and format.). Student participants were each asked to complete an online survey and to provide feedback on the strengths and weaknesses of the program, the student's learning gains over the eight-week program, areas for program improvement and program impacts on student interest in advanced study and/or careers in homeland security. Out of the 13 student participants, 12 students completed the program survey.

A majority of the student respondents rated the SRI "Excellent" in the following categories:

- Quality of Program Coordination/Administration (75%)
- Faculty Mentor Guidance and Assistance (75%)
- Quality of Program Curriculum (66.7%)
- Quality of Faculty Lectures (66.7%)
- Quality of Guest Lectures (75%)
- Quality of Field Trips (83.3%)
- Quality of Teamwork (66.7%)
- Quality of Research Facilities (75%)
- Quality of Research Outcomes (50%)
- Ability to be Innovative and Self Motivated (66.7%)

In only one category, "Quality of Teamwork", did two students report ratings of "Not Good at All".

91.2% of the survey respondents (11 out of the 12 students) said that the SRI enhanced their interest in advanced academic study and careers in the homeland security domain and 100% of the students reported that they would recommend the program to their peers and colleagues at their respective schools.

When asked to what extent the SRI enhanced or improved their skills, a majority of the students reported “Significant Improvement” in the following areas:

- Ability to Conduct Research (66.7%)
- Oral Presentations (58%)
- Professional Confidence (50%)
- Teamwork/Collaboration (50%)

When asked to reflect on their “Top 3 Takeaways” from the program, the students commonly mentioned the following:

- Increased public speaking and presentation skills,
- A better understanding of research,
- A deeper understanding of the maritime domain and security technology,
- Friends

The students worked in close collaboration with MSC researchers and had the unique opportunity to interact and engage with real-world industry and government maritime and homeland security leaders and practitioners. Through their experience in the summer research program, students gained a greater awareness of maritime security issues and the vital role of the MTS to the nation’s economy. Because of their experience in the SRI program, several of the students will now consider seeking jobs and careers in areas that will contribute and support to U.S. homeland security. Overall, the SRI was effective in achieving the following outcomes:

- Student research reports, field experiments and weekly presentations demonstrated the student’s advanced knowledge and understanding of the maritime security domain.
- Students enhanced their professional skills by providing weekly research presentations and through networking opportunities with MSC stakeholders.
- A majority of the students expressed enhanced interest in pursuing careers and/or advanced academic study in maritime/homeland security as a result of their participation in the SRI.

3.4.9. SRI Lessons Learned

MSC continuously strives to enhance the learning experiences of its student participants by modifying and adjusting the SRI program format. Lessons learned over the past year have led the Center to limit the student orientation period from two weeks to one week. By adjusting the program accordingly, the students were afforded more free time to conduct and complete their research assignments within the eight-week program format.

Upon considering SRI mentor feedback and the student survey responses, the Center will also explore modifying the admission requirements for the program. Overall, 15 students were selected to attend the program, however, two students withdrew their decisions to attend shortly before the start of the program. The reduced number of students did impact the balance of students on one of the summer research teams. Going forward, the Center will work to better screen the program applicants to ensure their commitment to the eight-week program.

3.4.10. SRI Alumni Network

MSC administrators continue to cultivate an active and engaged SRI alumni network. Responding to feedback from the Center's alumni, the Center created an MSC SRI Alumni Group on the professional online network, LinkedIn. The purpose of the LinkedIn group is to stay abreast of alumni professional activities and careers, and to exchange information pertinent to maritime security and research topics. To date, the group includes forty former SRI students from the 2010-2015 programs. Group discussions have included suggestions for MSC seminar topics, and one student has requested her former colleagues to follow her maritime observations blog.

Students from the current SRI program have begun to join the group as well.

3.5. Maritime Security Master's and Doctoral Fellowship Programs

Milestone	Performance Metrics	Status/Discussion
1. Degree requirements. CDG 2011 Master's Fellowship (11/1/14 – 8/30/15) CDG 2012 Master's Fellowship (11/1/14 – 6/1/16) CDG 2013 Doctoral Fellowship (11/1/14 – 6/1/17)	-CDG Master's degree fellows, currently three total, will enroll in nine credits per semester during their first two semesters, and a maximum of six credits during their third and fourth semesters of the fellowship. -CDG Master's degree fellows will complete a six-credit thesis requirement. -The doctoral fellow (one student) will complete an average of 28 credit hours of coursework and research each year over a three-year period.	Completed: Students maintained their requisite number of credits per semester.
2. Career Placement and post-program tracking. 2011 CDG fellow placement in a homeland security related position. 8/30/15 – 2/1/16. 2012 CDG fellow placement in a homeland security related position. (Milestone dates will be determined for the third	-Stevens CDG fellows will assume homeland security related employment within a period of six months following the completion of their degree programs. To date, one student will be eligible for placement in 2015 and two students will be eligible for placements in 2016.	Completed: All three eligible Fellows have successfully obtained HS related employment. A post program survey will be conducted within one year into the student's employment.

DHS CDG Master's fellow as soon as the student has been identified and the remaining 2012 award has been conferred.)	-CDG fellows will maintain employment in the homeland security domain for a minimum of one-year. -Student employment and professional activities will be tracked through a post program survey.	
3. Work plans will be created for new Career Development Supplements during Years 2. (2016)	-MSC will apply for additional Career Development Supplements, as they are made available through DHS OUP.	In process: No new supplement awards have been made available in YR 2.

3.5.1. MSC Supported Students

In addition to the five students supported by the MSC during the 2016 Summer Research Institute, the Center has also provided support to three graduate-level students in the form of Graduate and Doctoral Research Assistantships to Juan Pinales, Applied Marine Physics doctoral candidate, University of Miami, Blaise Linn, Maritime Systems Master's degree student, Stevens Institute of Technology and Carrick Porter, Maritime Systems and Computer Science Master's degree student, Stevens Institute.

Juan Pinales is currently engaged in a full-time doctoral degree program at the University of Miami and is conducting research in conjunction with his dissertation advisor and MSC PI, Dr. Hans Graber, Executive Director, CSTARS. Juan's research is focused around the detection of hydrocarbon films on the ocean surface. His research complements the work being conducted at CSTARS utilizing Synthetic Aperture Radar (SAR) sensor technology and air-sea interactions for developing strategies for improved detection of go-fast and semi- submersibles in coastal waters and open seas.

Juan holds a Bachelors of Engineering in Engineering Science, from Stony Brook University and completed graduate work through a NOAA-CREST Graduate Student Fellowship at the City College of New York, prior to the doctoral program at the University of Miami.

Blaise Linn is currently enrolled fulltime in the Stevens Institute of Technology Maritime Systems Master's Degree program with a concentration in Maritime Security. As an undergraduate student, Blaise participated in three MSC Summer Research Institute programs and proactively engaged in independent research projects with MSC researchers and Stevens Maritime Systems faculty members.

In January 2016, Blaise was sponsored by the DHS Office of University Programs to scout out new and emerging technologies at the 2016 Consumer Electronics Show (CES) in Las Vegas, NV. His responsibilities as a tech scout were to seek out and identify cutting edge technologies that could enhance the security capabilities and operational productivity of the maritime industry.

He was also responsible for preparing and submitting a report on the three top technologies that stood out to him at the CES and identify their capabilities and limitations, potential application in the maritime domain, and a cost benefit analysis for each. Following the CES, Blaise was invited to present his technology selections to the DHS S&T Under Secretary Dr. Reginald Brothers and Deputy Under Secretary Dr. Robert Griffin at a DHS OUP Directors meeting held on April 22, 2016 in Washington, DC. Blaise's CES report is available for review in the MSC publications webpage at https://www.stevens.edu/research-entrepreneurship/research-centers-labs/maritime-security-center/reports-publications.

Carrick Porter is currently enrolled fulltime in the Maritime Systems Master's Degree program at Stevens Institute of Technology. Carrick is an ROTC cadet, an MSC SRI program alumni and a former member of the Stevens USCG Auxiliary program. Carrick recently conducted research in Maritime Cybersecurity and completed an MSC draft whitepaper entitled *Emerging Issues in Maritime Cybersecurity.* The final paper will be made available in the publications section of the MSC website. Carrick holds an undergraduate degree in Computer Science, with a minor in Systems Engineering from Stevens Institute of Technology.

3.5.2. Mechanical Engineering and Homeland Security Doctoral Fellowship – DHS Career Development 2015 Supplement Award

In the fall of 2015 MSC received supplemental funds to support a fully-funded Doctoral Fellowship in Mechanical Engineering and Homeland Security. Following a competitive review process coordinated by a committee of Stevens Mechanical Engineering and Maritime Security faculty members, together with MSC research PI's, Mr. John Martin was selected to receive the 2015 Doctoral Fellowship award.

John completed an undergraduate degree in Physics and Aerospace Engineering at the University of Maryland and engaged in graduate-level course work in Computer Science at Columbia University. John's research involves the use of unmanned systems for maritime security applications. His interdisciplinary research will focus on the development of algorithms that enable robots, e.g. underwater vehicles, to effectively navigate in the presence of uncertainty. His dissertation advisor is Dr. Brendan Englot, Assistant Professor, Stevens Mechanical Engineering Department.

During the 2015/2016 academic year, John completed 18 credits towards his PhD requirements, passed the Mechanical Engineering qualifying exams, and engaged in the following courses and activities:

Semester	Course	Credit
Summer 2016	Successfully passed the Mechanical Engineering Doctoral Qualification Exam	
Spring 2016	ME621: Intro. to Modern Control Engineering	3
Spring 2016	ME631: Mechanical Vibrations	3

Spring 2016	ME960: ME Doctoral Dissertation Research	3
Fall 2015	ME598: Intro. to Robotics	3
Fall 2015	ME 641: Engineering Analysis I	3
Fall 2015	ME 651: Analytic Dynamics	3
Fall 2015	ME 960: ME Doctoral Dissertation Research	3

*Note: Credits earned in ME 960 do not receive weighted grades. "S" means that the students successfully registered and completed credits toward their research requirements.

Fellowship and Research Activities

- USMMA ROV field-based Experiment – June 20, 2016 and April 22, 2016
- Evaluator – Maritime Transportation and Commerce Security TTX – May 25, 2016
- NY Academy of Sciences Machine Learning Conference – March 4, 2016
- Hudson River Park ROV Experiment – November 20, 2015
- USMMA ROV field-based Experiment – November 18, 2015
- 6th Annual Maritime Risk Symposium - November 16, 2015
- NJ Tech Council Drone Conference - September 17, 2015

3.5.3. Maritime Security Doctoral Fellowship - DHS Career Development 2013 Supplement Award

Alex Pollara was awarded the Maritime Security Doctoral Fellowship in June 2014. Alex's research is centered on the use of machine learning algorithms to automatically characterize and classify vessel acoustic signatures. Alex's work in this area has contributed to the MSC's development of a Passive Acoustic Recording Systems (PARS). PARS operates on a small lightweight microcomputer that enables the system to process passive acoustic data in near real-time. The system is being designed to be deployable in a variety of remote and/or hidden locations and can be used to provide the forensic information needed to determine if intrusions have occurred and the likely source of the intrusion (e.g., small boat, swimmer, or unmanned undersea vehicle). The collected data can help the U.S. Coast Guard and other law enforcement entities detect illegal vessel traffic and intruders in maritime and port security zones. He recently demonstrated the system at a DHS OUP Technology Showcase held on May 19, 2016 at the Stevens Institute of Technology offices in Washington, DC.

Alex's contributions have also included the mentorship of a multidisciplinary Senior Design Team, in conjunction with Stevens' faculty and research engineers Dr. Alexander Sutin and Dr. MG Prasad, during the 2015/2016 academic year. The senior design team investigated the application of a microcomputer for acoustic signal processing inside a buoy to send alerting information to a command center. The project built upon passive acoustic research conducted by the Maritime Security Center and leveraged buoy equipment developed by a Stevens senior design team during the previous academic year. The team's work was showcased at Stevens Senior Design and Innovation Expo held April 27 at the Stevens campus in Hoboken, NJ.

In Year 2, Alex completed 18 additional credits towards his doctoral degree, for a total of 36 towards his PhD requirements, and has engaged in the following courses and activities:

Semester	Course	Credit
Spring 2016	OE 800: Underwater Acoustics	3
Spring 2016	OE 960: Research in Underwater Acoustics	6
Fall 2015 – Spring 2016	Mentored Stevens Senior Design Research Team	
Fall 2015	CS 559: Machine Learning: Fundamentals and Applications	3
Fall 2015	OE 960: Research in Ocean Engineering	6
Fall 2015	Successfully passed both Oral and Written PhD Qualifying Exams	
Summer 2015	Research Mentor – Underwater Acoustic Systems Team – SRI 2015	
Spring 2015	OE 960: Research in Ocean Engineering*	3
Spring 2015	CPE 695: Applied Machine Learning	3
Spring 2015	BIA 656: Statistical Learning & Analytics	3
Fall 2014	EE 548: Digital Signal Processing	3
Fall 2014	OE 560: Fundamentals of Remote Sensing	3
Fall 2014	BIA 652: Multivariate Data Analysis	3
Summer 2014	Research Mentor – Sensor Technologies Team – SRI 2014	

*Note: Credits earned in OE 960 do not receive weighted grades. "S" means that the students successfully registered and completed credits toward their research requirements.

Fellowship and Research Activities:

- Represented the MSC at the DHS OUP Technology Showcase, May 19, 2016.
- Conducted experiment with enhanced underwater recording platform at USMMA, June 20, 2016.
- Passed Oral and Written PhD Qualifying Exams – Fall 2015.
- Attended 6th Annual Maritime Risk Symposium – November 16-17, 2015.

- Mentored Stevens Institute of Technology Senior Design Capstone Project - 2015/2016 academic year.

Publications and abstracts:

Alex has prepared two papers that have been accepted for presentation at the Oceans 2016 Conference, sponsored by the Marine Technology Journal and IEEE, to be held September 19-23, in Monterey, CA.

The two papers include:

- *Feature Extraction for Acoustic Signatures of Small Boats, and*
- *Improvement of the Detection of Envelope Modulation on Noise (DEMON) and its application to small boats*

Early in 2016, he also co-authored a paper for the publication Technology and Culture. The citation for the publication is as follows: Ferreiro, Larrie D., and Alexander Pollara. "Contested Waterlines: The Wave-Line Theory and Shipbuilding in the Nineteenth Century."

3.5.4. DHS Career Development Master's Degree Fellows – 2012 Award

In Year 2, three students were enrolled in the MSC Maritime Systems Master's Degree Fellowship program. Two out of the three students fulfilled their fellowship and degree requirements to receive their Master's degree, and one student remains in the program. The three Fellowship students include Nicholas Haliscak, Hasan Shahid, and Tyler Mackanin.

In December 2015 **Nicholas Haliscak** completed his degree requirements to receive a Master's degree in Maritime Systems and a Graduate Certificate in Maritime Security from Stevens Institute of Technology. During the 2015/2016 academic year, Nicholas completed his course work and a master's thesis in entitled *Use of System Parameters to Augment Autonomous Navigation.*

He also participated in the 6th Annual Maritime Risk Symposium, co-hosted by the USCG Research and Development Center and MSC. Nicholas is now employed as a general engineer (GS7) with Logistics Support Activity (LOGSA) at the US Army's Redstone Arsenal, in Alabama.

Hasan Shahid also completed his fellowship and master's degree requirement during Year 2. In May 2016 Hasan received a Master's degree in Maritime Systems with a Graduate Certificate in Maritime Security from Stevens Institute of Technology. Following the completion of his degree, Hasan was offered and accepted a position with LMI as a Junior Engineer. Hasan's responsibilities will include engineering support for the National Urban Security Technology Laboratory, where he will evaluate and test technologies for use by emergency responders and law enforcement.

Prior to completing his degree, he completed a master's thesis that dealt with developing a simplified performance evaluation model to estimate the maximum detection range of maritime targets by a frequency modulated continuous wave (FMCW) radar.

The remaining student in the 2012 CDG Fellowship award program is **Tyler Mackanin.** In Year two, Tyler engaged in coursework fulltime and participated in a ten-week field-based internship with the Homeland Security Studies and Analysis Institute (HSSAI) Falls Church, VA, during the summer of 2016. In this capacity, Tyler is conducting research on increased maritime activity in the Arctic and the impacts it is having on the role and responsibilities of DHS component agencies in the region. He is also contributing to a person-based vetting and screening task, in which an in depth analysis is being conducted on all of the "vetting" systems that are currently being used by DHS component agencies, including TSA, CBP, and ICE among other.

In Year 2, Tyler completed 9 additional credits towards his degree and engaged in the following fellowship and research activities.

Semester	Course	Credit
Summer 2016	Homeland Security Studies and Analysis Institute – Field-based Internship (May – July 2016)	
Spring 2016	Technologies in Maritime Security	3
Spring 2016	Marine Transportation	3
Spring 2016	Advanced Maritime Security	3
Fall 2015	Probability & Stochastics	3
Fall2015	Maritime Safety & Security	3
Fall2015	Fundamentals of Remote Sensing	3
Summer 2015	Team Leader: Magello Emergency Response Team – SRI 2015	

Fellowship and research activities:

- Participated in the Maritime Risk Symposium – November 16-17, 2016
- Prepared two course-based research papers entitled *Probability of an accident occurring in the Panama Canal* and *Detection of oil spills with Synthetic Aperture Radar*

Table 8. Summary of DHS CDG Fellowship Student Activities & Stakeholder Engagement.

Student	Program Start/End	Background	MSC Research Activities and Stakeholder Engagement
Nicholas Haliscak	Jan. 2014 – Dec. 2015	MS in Maritime Systems with a Graduate Certificate in Maritime Security, B.Eng in Mechanical Engineering, TAMU-Kingsville	-Employed as a General Engineer in the Logistics Division at the US Army's Redstone Arsenal in Alabama. -Completed degree requirements and master's thesis, and fulfilled fellowship obligations in December 2015. -USCG Research and Development Center – 2015 field-based Summer Research Intern.
Tyler Mackanin	June 2015-expected graduation May 2017	B.Eng in Naval Engineering, Stevens Institute of Technology	-HSSAI field-based internship, Falls Church, VA– Summer 2016. -Engaged in the MSC 2015 Summer Research Institute. -Participated in the 6th annual Maritime Risk Symposium.
Hasan Shahid	June 2014 – May 2016	-MS in Maritime Systems with a Graduate Certificate in Maritime Security -B.Eng. in Electrical Engineering, Stevens Institute of Technology	-Employed as a Junior Engineer with LMI. -Research mentor SRI 2016 -USCG Research and Development Center field-based Summer Research Intern. -Participated in the 6th annual Maritime Risk Symposium.

3.5.5. Maritime Systems Master's Degree Fellowships

Research conducted by the Maritime Systems Master's and Doctoral Fellowship students is directly linked to the ongoing and evolving research conducted through the MSC. As part of the DHS CDG-funded program, the fellowship recipients are required to engage in multidisciplinary research-based projects in conjunction with MSC researchers in the Summer Research Institute and in field-based internships with Homeland Security operators.

The DHS CDG-funded students must also complete an in-depth research project in the form of a Master's thesis at the culmination of their degree programs.
In Year 2, Alex Pollara and John Martin each engaged in research experiments in conjunction with MSC research PIs and Stevens' faculty members. Alex's research supports the Center's work in the area of passive acoustic detection systems and John's research is broadening the Center's scope and research into the use of unmanned systems for maritime security applications.

Additional student contributions and engagements include Blaise Linn and Hasan Shahid's involvement in MSC and USCG projects related to mobile platforms for maritime domain awareness, and Carrick Porter's research in Maritime Cybersecurity, and new and emerging area of research for the Center.

3.5.6. MSI Outreach and Engagement in Research

Milestone	Performance Metrics	Status / Discussion
1. Minority and women student participation in the Center's annual Summer Research Institute. SRI 2016 – outreach and recruitment (9/1/15 – 2/26/16)	- Diversity in the SRI program will reflect a minimum of 50% women and minority student participants. -MSI outreach and recruitment efforts will be assessed by the number of targeted email communications and personal conversations with women and minority student-focused professional societies (SWE, NSBE, SHPE student chapters) and email announcements distributed through DHS OUP MSI contacts and channels.	Achieved: 53% of the SRI 2016 participants were students from underrepresented communities (e.g. women and minority students.) Two DHS OUP Summer Research Institute student recruitment email announcements were sent out to MSI contacts and COE representatives (totaling more than 85 contact points per mailing.) in January and February 2016. MSC participated in the DHS OUP LEAP Workshop held in March 2016. The workshop included participation by 15 MSI schools. Networking at the event facilitated an exchange of business cards and contacts. One student participant from TSU was successfully recruited to attend the SRI 2016 program.

2. MSI participation in MSC research activities/programs. Summer Research Team program YR 2 – 6/6/16 – 8/12/16 Scientific Leadership Awards (SLA) YR 2 – 7/1/15 – 6/30/16	-MSC will host a minimum of one MSI SRT team per summer. -Outreach efforts to recruit MSI SRT participation will be measured by the number of targeted email distributions and personal conversations had with MSI representatives. -Outreach in the form of targeted emails and personal conversations with MSI schools will be conducted to encourage MSIs to prepare SLA proposals in conjunction with the MSC. -SLA proposals will include MSI faculty and student participation in the Center's summer research program and in other ongoing research initiatives.	New Mexico State University (NMSU) was awarded an MSI SRT award to collaborate with the MSC. NMSC withdrew from the MSI SRT one month prior to the start of the summer research program. MSC therefore did not host an MSI SRT team in 2016. Completed: MSC reached out to a minimum of five MSI schools (ECSU, TSU, CityTech, UPRM, and Howard University) to recruit schools to collaborate with on an SRT proposal during Year 2.

In the fall of 2015, MSC put forth efforts to host an MSI Research Team through the DHS OUP Summer Research Team Program. Following an extensive review and conference call discussions, MSC and a faculty and student research team from New Mexico State decided to collaborate and partner on a research proposal in the area of passive acoustic underwater threat detection to include electro-optics, in particular underwater light detection and ranging (LIDAR) systems.

Upon submission to the DHS SRTP administrators, the proposal was selected for an award and plans were made to host the summer research team at the Stevens Institute of Technology campus in Hoboken, NJ. One week prior to the start of the program however, the team from New Mexico State withdrew their participation in the program citing a conflict in their research schedule. Due to the timing of the cancelled research project, MSC did not have sufficient time to convene and arrange for another MSI research team.

Leading up to the selection of New Mexico State University team members, the MSC director of education conducted outreach to the Center's academic partners and MSI contacts (ECSU and TSU) to identify potential SRTP projects and collaborators.

In addition, MSC's director of education participated in the DHS OUP Minority Serving Institution Leveraging Expertise in Academia for Placement (LEAP) Workshop, held on March 30, 2016, in Washington, DC. The Workshop was coordinated by OUP to facilitate an opportunity for DHS stakeholders and COE's to interact with DHS MSI partners and to identify potential synergies for future collaborations.

Faculty and students from approximately 15 MSI colleges and universities showcased research projects, accomplishments, and course content that had been developed with S&T funding through collaborative efforts with Centers of Excellence. During the Workshop, MSC's director of education made several new contacts and successfully recruited one student from Texas Southern University to attend the Center's 2016 Summer Research Institute.

3.5.7. USCG Auxiliary University Programs at Stevens Institute of Technology

Milestone	Performance Metrics	Status / Discussion
1. USCG Auxiliary on-campus student meetings. 8/29/15 – 5/7/16	-Meetings will occur once a month during the Stevens academic year. -Student member dues are required annually, each November. (2015 and 2016).	Not Completed: The Stevens Detachment did not meet monthly due to circumstances with the Flotilla mentors and the attrition of the student members.
2. New member recruitment. 8/29/15 – 5/7/16	-Student recruitment is continuous and will include participation in Stevens Club Fair events, announcements in the Stevens Student Life Newsletter and through campus posters. -The Stevens-based Auxiliary program will recruit a minimum of two new members each academic year to ensure sustainability of the campus-based program.	Not Completed: Due to the postponement of the on-campus monthly meetings, no new members were recruited.
3. USCG Auxiliary student activities. 8/29/15 – 5/7/16	-Completion of online and on-site training requirements will be completed as directed by the USCG Auxiliary. -Student community service and field- based activities will include a minimum of two organized events per academic year. (e.g. harbor patrols with the USGC or Aux education outreach at community events.)	Not Completed: While efforts were made to create opportunities for Stevens USCG Auxiliary members to participate in trainings, meetings and activities with the Lower Manhattan Flotilla, Stevens members did not attend on a routine basis during Year 2.

During Year 2, the Stevens USCG Auxiliary Detachment Unit suspended its monthly meetings in part due to a lack of USCG Auxiliary mentor availability and engagement and the attrition of members in the Stevens Detachment.

In lieu of the Stevens based activities, the three remaining members in the Stevens Unit were invited to attend meetings and trainings at the Lower Manhattan Flotilla, located in New York City. MSC administrators also worked with Auxiliary members from Lower Manhattan Flotilla and the emerging Detachment hosted by John Jay College of Criminal Justice to identify a schedule of trainings and activities for new recruits to attend.

To date, MSC is still working with these groups to leverage their Flotilla support to establish a joint program for Stevens' students and administrators to attend.

4. Other Related Activities

This section briefly describes additional activities related to MSC that occurred during the reporting period. These include the M3DA (Mobile/Modular Maritime Domain Awareness) project, Maritime Risk Symposium, outreach activities, and Management and Committee meetings.

4.1. Maritime Risk Symposium

The Maritime Security Center (MSC) in conjunction with the U.S. Coast Guard Research and Development Center (RDC) co-hosted the 6th Annual Maritime Risk Symposium (MRS) on November 16 - 17, 2015, at the Stevens Institute of Technology campus in Hoboken, NJ. The theme of the Symposium was Risk in the Western Hemisphere and Southern Border Approaches. The Commandant of the USCG, Admiral Paul F. Zukunft provided the keynote address discussing growing areas of concern for homeland security and the maritime community, including transnational organized crime, maritime border security and cyber security threats. The Admiral's talk followed the USCG's release of its Cyber Strategy earlier in the summer.

The 2015 MRS Chairs included Dr. Joseph DiRenzo III, Partnership Development Director at the USCG RDC (then Senior Advisor to the Area Commander for Science, Technology and Innovation, USCG Atlantic Area) and Dr. Julie Pullen, Associate Professor at Stevens Institute. The Program Co-Chairs were Captain Bruce Clark, Director, Maritime Safety and Security Center, CSU Maritime Academy and Dr. David Boyd, Operations Analysis, USCG Pacific Area.

The two-day event drew close to 150 attendees representing a diverse group of national and international maritime representatives. Panel discussions and keynote speakers led discussions on combating criminal and terrorist networks, safeguarding commerce and the Marine Transportation System (MTS), cyber security threats to the maritime domain, and data sharing across the industry and government maritime enterprise. A copy of the program agenda, together with a list of presenters can be found on the MRS 2015 website at: https://www.stevens.edu/research-entrepreneurship/research-centers-labs/maritime-security-center/maritime-risk-symposium.

The 6th Annual Maritime Risk Symposium served as a forum to inspire and generate areas of study and future research projects for the DHS S&T Center of Excellence researchers, students and academic partners. The main objective of the Symposium was to encourage participants to identify critical research areas where academia could help contribute solutions to the maritime risk arena.

Outcomes from the Symposium included a number of research questions that are of particular interest to DHS and its component agencies. A summary for each of the panel talks, together with the corresponding research questions generated was prepared and is available for public review on the MSC/MRS website at: https://www.stevens.edu/research-entrepreneurship/research-centers-labs/maritime-security-center/maritime-risk-symposium/2015-summary-report. As a result of the symposium discussions and research questions raised, MSC issued a Request For Proposal competition as described next.

4.2. MSC Request for Proposals and White Papers

MSC issued a Request for Proposals (RFP) as part of its ongoing efforts to solicit research ideas for new Center projects through RFPs as well as requests for White Papers. These requests will be to answer research questions posed in the Center's Funding Opportunity Announcement (FOA) as well as the in the Integrated Product Team (IPT) summary. Proposals aligned with the FOA and IPTs will be evaluated for possible funding. The next section briefly describes the RFP that was issued during the reporting period.

Following the 2015 Maritime Risk Symposium, co-hosted by the Maritime Security Center (MSC) and the U.S. Coast Guard Research and Development Center, MSC prepared a Request for Proposals for research to be conducted related to Maritime Cyber Security. On March 28, 2016, MSC engaged in an extensive outreach campaign, to include a broadly distributed email announcement and a dedicated web page to solicit proposals. The effort invited qualified researchers to propose projects that would provide DHS stakeholders with innovative research to address current challenges in maritime cyber security. The MSC made available one award of up to $350,000 for a performance period of up to two years.

This RFP aimed to solicit answers to the following research questions:

1. What risk-based performance standards can be developed for cyber risk management of the Marine Transportation System (MTS)? How would performance standards inter-relate with other infrastructure sectors and their performance standards? How would performance standards inter-relate with existing safety and security management systems?

2. What type of criteria should be utilized to develop an academically rigorous framework for Cyber Policy for the MTS?

3. Based on a multi-node analysis, what are the critical Points of Failure within the cyber system supporting the MTS?

4. What are the critical requirements that should be considered when developing an academically rigorous and multi-use Maritime Cyber Range?

5. What methodologies can be utilized or invented to develop a framework to analyze a point of Failure Detection Methodology?

6. What methodologies can be employed to conduct a quantitative analysis of maritime cyber deterrent strategy effectiveness?

MSC received several high-quality proposals by April 25, 2016 (RFP deadline). The proposals were each evaluated by DHS S&T Office of University Programs and assessed according to the rigorous set of evaluation criteria. ABS consulting was awarded the research project on Maritime Cybersecurity, expected to start in the fall of 2016.

4.3. Communications and Outreach Activities

MSC continued to host visitors and partner with various key stakeholder organizations in a range of activities (Symposiums, research experiments, trainings and exercises). MSC has partnered with the RDC, USCG Sector NY, Customs and Border Protection, Immigration and Customs Enforcement, National Urban Security Technology Lab, the NYC Police Department, NY Office of Emergency Management, NJ Office of Homeland Security and Preparedness, and others as described below.

USCG RDC

- MSC and USCG RDC partnered to plan and co-host the 2015 Maritime Risk Symposium. More than 150 participants attended the two-day Symposium held at Stevens Institute of Technology. A summary report of the panel discussions is available on the MSC website at https://www.stevens.edu/research-entrepreneurship/research-centers-labs/maritime-security-center/maritime-risk-symposium.

- MSC Master's Degree Fellows engaged in ten-week internships at RDC in New London, CT and engage in experiments as part of the 2015 Arctic Shield exercises aboard the USCGC HEALY.

USCG Sector New York

- On August 25, 2015, CAPT Michael Day, the newly then appointed Commander of U.S. Coast Guard Sector New York and Captain of the Port of New York/New Jersey, visited Stevens to learn about the Center's research in Maritime and Port Security applications.

- MSC’s Director of Education, together with its academic partners from LSU serve as members of the Sector NY Area Maritime Security Committee – Cyber Subcommittee. The Sector New York AMSC Cyber Subcommittee was formed in 2015 to support the Coast Guard's Cyber Strategy and to enhance the cybersecurity awareness and posture of the Port of New York/New Jersey.

NUSTL

- MSC administrators and students participated in NUSTL's first annual Operational Experimentation (OpEx) Exercise.

CBP

- MSC representatives participated in a tour and attended a meeting with the Chief Watch Commander at the CBP National Targeting Center in Herndon, VA.

- CBP's Office of Field Operations at the Port of NY/Newark hosted MSC students and faculty mentors for a tour of the agency's cargo scanning equipment and facilities.

- CBP Officers discussed research ideas and projects with MSC administrators and students.

NYPD-Counter Terrorism Division

- MSC administrators and students were invited to attend a Port Awareness and Response training hosted by the NYPD-CTD.

- MSC students and researchers continued to support NYPD-CTD in Maritime Simulator research.

- NYPD-CTD hosted SRI students for an acoustic data experiment.

NJ OHSP

- NJ OSHP met with MSC and LSU to provide input and discuss the Center's plans to develop discussion-based tabletop exercises.

- MSC administrators and students served as evaluators in for a Transportation and Commerce Security Tabletop Exercise (TTX), hosted by the NJ OHSP.

Other Activities

- MSC also hosted a group of maritime education and port facility professionals from Durban, South Africa as part of the U.S. State Department's International Visitor Leadership Program and Maritime Education and Management project.

In addition to the above, MSC conducted many targeted communications activities. This included participation in the following events:

- OUP Technology Showcase
- MSI LEAP Workshop

- OUP Virtual Technology Showcase
- Consumer Electronics Showcase
- OUP COE Education Representatives Meetings

The Center also generated and distributed a bi-monthly newsletter. The newsletter contains relevant information regarding the Center's research, stakeholder engagements and student achievements.

4.5. Management Activities

The main COE management activities are summarized in this section. The Center Executive Director and Director worked with the COE's Principal Investigators (PIs) to develop project work plans and discussed project content that will benefit DHS and its stakeholders. The Director worked closely with the DHS Program Manager and spoke with him on a weekly basis to understand DHS expectations from the Center and bring up any issues of concern. In addition, the Director met with the Director of OUP to discuss his expectations. Based on these discussions and meetings, the Director held frequent meetings with individual PIs as well a meeting with all the PIs every six weeks. The purpose of these meetings was to ensure that the individual projects are progressing according to the work plans.

During the reporting period, the overall Principal Investigator for the Center left Stevens institute at the end of 2015. This required the appointment of a new PI, also serving as the Center director. Quarterly reviews were not held with the research PIs for the current period. During the first half of the year, such meetings may have helped in correcting project issues early on (see below for missed milestones). To correct this, the Center management started to hold regular calls with the PIs every six weeks to discuss project progress according to the work plan. In addition, the Center director held calls with each research PI individually on a regular basis to discuss issues to specific to each project and discuss corrective action if needed.

Members the Center Science and Education Advisory Committee (SEAC) attended the Maritime Risk Symposium. Three of our the members play significant roles in the MRS. USCG (retired Admiral) Robert Parker was a part of the MRS planning committee and served as the master of ceremonies at the Symposium. Bethann Rooney (Port Authority of NY and NJ) was a panel moderator for the Safeguarding Commerce panel and Lilian Borrone organized a panel for Combatting Networks.

For planned faculty exchanges, the Center planned to have an MSI Summer Research Team from New Mexico State University. However, the team withdrew their participation three weeks prior to the start of the program. The Center also had some discussions with faculty from the USCG Academy, but these discussions did not lead to any exchanges during the reporting period.

Among other management activities, the COE responded to one project not proceeding as planned. The Satellite Surveillance project milestones were not met and the PI failed to communicate the issue to the Center Executive Director or the DHS PM. The issue did not become known until September 2015, when a meeting was held at the University of Miami to discuss the project among DHS and the key stakeholders (DHS Border and Maritime Division and CBP's Air and Marine Operations). In addition, sensitive information was presented during the meeting. Since this is in violation of the Center Cooperative Agreement, corrective action was taken by implementing the procedures outlined in the Information Protection Plan. Also, the plan was updated and distributed to the research PIs. As a result, the project funding was restricted until the PI worked with DHS BMD and the AMOC principals to develop a revised work plan that was acceptable to all parties. Once this was completed, the funding was released and the project is now proceeding as planned. To avoid such an occurrence from happening in the future, the Center Director communicates on a regular basis with the PIs to make sure the milestones are being met and there are no roadblocks.

In addition to the above activities, the Center director has reached out to many DHS stakeholders and discussed their projects and how the Center can be a resource to them. The Center director met on more than one occasion with the DHS BMD director, the BMD deputy director, various Program Managers, the USCG RDC leadership and Program Managers, and key stakeholders from the USCG, ICE, and CBP.

4.6. Center Guidelines and Policies

During Year 1 MSC administrators created a document for the Center's academic partners and research PIs containing general orientation information (e.g. partner contact information, reporting requirements, and DHS acknowledgement and disclaimer statements), and copies of the Center's policy and security requirements for handling sensitive material, as well as student safety and security guidelines. The MSC General Information and Guidelines for Academic Partners document was updated in Year 2 and shared with each of the MSC partner schools, with the requirement that they acknowledge receipt and confirm that they have reviewed and understand the policy and security requirements for handling sensitive material and the student safety and security guidelines.

Appendix 1 – Port Resiliency References, Biography, and Derivation

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Appendix: Definition of time dependent resiliency

A generic time dependent resiliency plot is shown in Figure 1 (a) for an increasing service system and Figure 1 (b) for a decreasing service system [9]. An increasing service system is one where network output is positively correlated with service; that is, as the output increases, so too does the service provided. An example of this is a production process where output, in terms of units built increases with the overall service of the production line. A decreasing service system is one where the network output is negatively correlated with the service. An example of this is dwell times; if a system is performing well, then dwell times should be minimized.

In Figure 1 (a) and (b), a system, noted as is analyzed before, during, and after a disruptive event. experiences three steady states: the original state , the disrupted state , and the stable state ; and two transitional states, where the systems transitions between the steady state and the disrupted state and another between the disrupted state and stable state. These transitions are marked by two events: the first event is the onset of the disruption () and the second is a recovery event. The figure illustrates how the initial system, as measured by its output performance , initially exists in a steady state. Then, due to the onset of a disruptive event, , transitions into a disrupted state. Finally, after the start of a recovery event, the systems transition into a stable state.

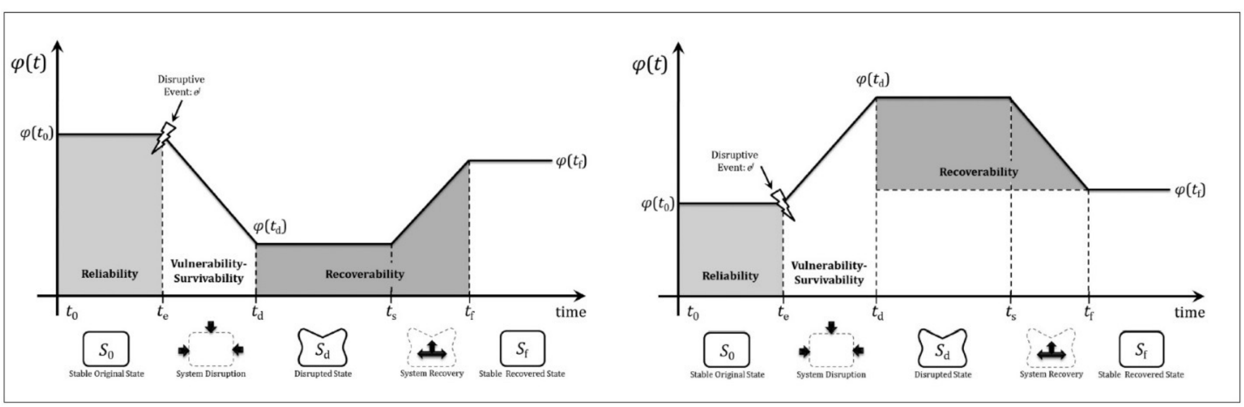

Figure 1 (a): Increasing Service System, (b) Decreasing Service System [9]

Using the time dependent resiliency function, Henry and Ramirez-Marquez (2012) [4] quantified resilience as the ratio of recover to loss. Therefore, resiliency at any time after event is calculated using the equation:

$$Я_{\varphi}\left(t_r \middle| e^j\right) = \frac{\varphi\left(t_r \middle| e^j\right) - \varphi\left(t_d \middle| e^j\right)}{\varphi\left(t_0 \middle| e^j\right) - \varphi\left(t_d \middle| e^j\right)} \; \forall e^j \in D$$

1

where,

= the resiliency of system *S* at time resulting from the disruptive event, .

= the performance of the system at , corresponding to the time of maximum service loss.

= the performance of the system at time, corresponding to the original state.

= the range of all disruption which could hinder service

Henry and Ramirez-Marquez (2012) made several important observations regarding the resiliency formulation, : (1) indicates the proportion of service which has been recovered by time , keeping in line with the meaning and intent of resiliency; (2) the minimum value of is zero, indicating that the system has not recovered from its disrupted state; (3) when the value of is equal to one the system has fully recovered at time ; (4) is undefined when , this indicates that no drop in performance was measured as a result of event, and therefore, is not an element of.

Appendix 2 – Seminar Series Survey Instrument

Thank you for participating in the MSC Seminar Series. Will you kindly provide us with your feedback on today's presentation?

Seminar: **XXXXXX**

Date: **XXXXXX**

1. How did you hear about the above Seminar? (check all that apply)

______Stevens Campus Announcement

______Colleague / Peer

_____MSC email announcement

_______Other (Please specify)

____

2. What best describes you? _____Student _____Faculty _____Staff

____DHS representative _____Maritime Industry representative ______Other

3. What inspired you to attend today's presentation? (check all that apply)

______The topic is relevant to my job / academic program

______I am personally interested in the topic

______I was hoping to learn new information that will assist me in my job/academic studies.

_____ Other (Please explain):
____

4. Did the seminar content meet your expectations?

____Exceeded my expectations

____Met my expectations

____I did not have any expectations

____Did not meet my expectations. I'm disappointed.

5. What other topics would you like future MSC seminars to cover?

Email: MSC@stevens.edu

Website: www.stevens.edu/msc

Appendix 3 – SRI 2016 Student Survey Instrument

* 11. How would you best describe your experience in the SRI?

* 12. What topics, lectures, and/or field visits did you find most interesting and engaging?

* 13. Has the SRI enhanced your interest in pursuing a career and/or further academic study in the field of maritime/homeland security?

- ◯ Yes
- ◯ No

* 14. Would you recommend the SRI to your friends and colleagues at your university/school?

- ◯ Yes
- ◯ No

* 4. To what extent has the SRI enhanced or improved your skills in the following areas?

	1=Not at all	2=Somewhat (Very little improvement in this area.)	3=Improved Sufficiently (My skills have improved and I can effectively apply what I have learned.)	4=Significantly Improved (I have significantly improved my skills and I feel confident in my capabilities in this area.)
Ability to Conduct Research	○	○	○	○
Communication Skills	○	○	○	○
Leadership Skills	○	○	○	○
Networking	○	○	○	○
Oral Presentations	○	○	○	○
Professional Confidence	○	○	○	○
Teamwork/Collaboration	○	○	○	○
Writing Skills	○	○	○	○

Other (please specify)

* 5. In your opinion which of the skills above did you improve the most and what activities in the SRI helped you improve these skills?

6. What skills would you have liked to improve more? (e.g. writing, networking, etc.)

2

* 7. Rate the SRI with regards to the following items:

	1= Not good at all	2= Good	3= Very Good	4= Excellent
Quality of Program Coordination/Administration	◯	◯	◯	◯
Faculty Mentor Guidance and Assistance	◯	◯	◯	◯
Quality of the Program Curriculum	◯	◯	◯	◯
Quality of Faculty Lectures	◯	◯	◯	◯
Quality of Guest Lectures	◯	◯	◯	◯
Quality of Teamwork	◯	◯	◯	◯
Quality of Field Trips	◯	◯	◯	◯
Quality of Research Facilities	◯	◯	◯	◯
Quality of Research Outcomes	◯	◯	◯	◯
Ability to be Innovative and Self Motivated	◯	◯	◯	◯

* 8. What are your top 3 takeaways from this summer's program? (We would like to quote your responses, so please provide as much detail as possible.)

* 9. What would you say are the strengths of the SRI? (e.g. Administration, faculty interaction/collaboration, student team work/collaboration, meetings with stakeholders, research assets, field visits, field experiments, networking opportunities, etc.) Please provide as much detail as possible.)

* 10. What can the Maritime Security Center do to improve the Summer Research Institute for future student groups? (Please provide as much detail as possible.)

* 11. How would you best describe your experience in the SRI?

* 12. What topics, lectures, and/or field visits did you find most interesting and engaging?

* 13. Has the SRI enhanced your interest in pursuing a career and/or further academic study in the field of maritime/homeland security?

◯ Yes

◯ No

* 14. Would you recommend the SRI to your friends and colleagues at your university/school?

◯ Yes

◯ No

Appendix 4 – Stakeholder Survey Questions

A set of questions in several categories (I-VIII) is used to elicit responses, in support of developing a resilience index. The list of questions has been submitted to IRB for approval.

Resilience for Maritime Ports
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1. Port/Agency ________________________
2. What is your official designation/position?
3. Please briefly describe your role:
4. What is your area of expertise? I prefer not to answer___
5. How many years have you worked at this port/agency? (Circle/check the appropriate choice)
   a. 0-2 years
   b. 2 -5 years
   c. 5-8 years
   d. 9-10 years
   e. 10-15 years
   f. 15 years or more I prefer not to answer__

I. Hazards:

1. What are the main hazards/threats faced at the port? (Please check all that apply)
   a. Hurricanes
   b. Flooding
   c. Oil Spills
   d. Accidents
   e. Worker Strikes
   f. Cybersecurity risks
   g. Other: Please specify

I. (A) Planning and Preparedness for Hazards and Threats: **Does your Port:**	
1	Have a hazard or emergency preparedness plan:
2	Contingency plan
3	Identify and prioritize the critical facilities and services to be restored in order for the Port to resume normal operations (e.g., berths and wharves, roadways, rail, terminal equipment, storage facilities)?
4	Identify critical business processes (e.g., email, payroll, purchasing, accounts payable, business support, etc.) and priorities for post-event restoration?

5	Use simulations/drills and scenario planning tools?
6	Utilize the Incident Command System framework for critical functions and responsibilities of Essential Personnel?
	Have Essential Personnel participate in the National Incident Management System's (NIMS) trainings?
	At least every 18 months, conduct emergency planning or training exercises with the management staff to practice response plans and procedures for various emergency scenarios?

Please indicate if you can share any relevant documents/plans:

(B) Hazard Assessment: **Does your Port:**	
1.	Conduct a regular assessment of critical infrastructure and facilities to identify potential threats?
2.	Perform assessments to identify infrastructure and facility upgrades necessary to limit damage due to flooding/storms? ,
3.	Follow FEMA Floodmap Base Flood Elevation standards?
4.	Identify its cyber risk and possible mitigation procedures to address that risk?

(C) **Location of Critical Infrastructure Facilities**

1. Place a check mark in the column where your ports critical infrastructure and facilities are located. You may need to consult flood maps. If your critical infrastructure facilities are located in multiple areas, put a check in all that are applicable. Then put a check mark in the last column if the infrastructure or facility is functional after a disaster (assuming Scenario 1).

	Special Flood	**Storm**	**Infrastructure or facility**

Wastewater treatment			
Power grid			
Emergency Generators			
Communications systems			
Emergency operation			
Evacuation shelter(s)			
Medical facilities			
Critical record storage			

II. Communications:

Internal Port Authority Communications: **Does your Port:**	
1.	Assess capacity of its communications' assets that include telephone systems (landline; base station and handheld portables; cell phones; and satellite phones); internet systems, intranet systems; and radio systems (UHF/VHF; Marine Band VHF; Amateur/Hamm); and implement newer technologies, as needed?
2.	Has your Port identified the communications equipment and methods (e.g., twitter, radio, texting, etc.) required to communicate with Port personnel in the event of an emergency?
3.	Identify threshold criteria for issuing evacuation orders in coordination with local authorities?

Tenant and External Stakeholder Communications: **Does your Port:**	
1.	Designate someone to attend local harbor safety committee meetings?
2.	Work with the Coast Guard and the Corps of Engineers to identify and evaluate water transportation safety requirements and conditions?
3.	Coordinate internally and externally to communicate with tenants, as needed, for preparedness, response, and recovery?
8.	Require its tenants to provide a copy of their business continuity plan?
12.	Have a communications plans for tenants and external stakeholders?

III. Coordination and Decision-Making:

Mutual Aid Agreements	
1.	Do you have mutual aid or formal agreements with neighboring ports to provide emergency support operations (e.g., providing fuel for generators; water; food; people to help with cleanup)?
1.1	If yes: please provide a brief description of the agreement or if possible a link to the document:

Assessment of Coordination & Decision-Making	Strongly Disagree/ Disagree / Agree/ Strongly Agree/ Don't Know
We have a clear process for coordinating with other ports/agencies (e.g. USCG Port Coordination teams) during an emergency.	
We share cyber-security related critical information with other government maritime entities and stakeholders.	
We have adequate agreements for mutual aid and support with other juridictions.	
Coordination drills/exercises and training with other agencies/port prior to emergencies/crises have helped response during emergencies/crises	
We have regular meetings to coordinate with local/ state/federal agencies	
Decision-making processes during emergencies are clearly laid out and are effective.	
What other factors affect the success of coordination between agencies?	

IV. Operations Planning for Preparedness

Continuity of Operations Planning: Does your Port:	
1.	Have an organizational chart documenting the structure and role definitions of each relevant agency for the purpose of achieving a single overall point of coordination in emergency response and restoration?
2.	Identify the physical contributions of each major organization in its Emergency Plan?
3.	Have a plan to prevent flying debris by securing or moving equipment including gantry cranes, container equipment, intermodal transportation and facilities, buildings and high mast lighting, vehicles, and utilities?
4.	Consider the circumstances under which the power at the Port is shut off?
5.	Have a protocol to establish emergency reactivation of utilities after an event?
6.	Have a list of vendors and contact information to allow for quick scheduling of emergency response and recovery services (e.g., equipment, supplies, damage assessment, facility control, channel maintenance)?
7.	Do other government entities in the area have master service agreements for emergency response and restoration that could benefit the Port (e.g., highway cleaning equipment to clear debris from roads leading into and out of the port facility)?
8.	Have a pre-identified Damage Assessment Team (e.g., in-house or contractors) and the resources to conduct both an initial damage assessment and a formal damage assessment process, per FEMA regulations?
9.	Have berth space specifically identified for FEMA/MARAD Ready Reserve Force vessels?
10.	Have a plan to ensure that there is a navigable channel, a supply of potable water, a berth, and access to Navy Hospital Ships in the event of a disaster?
11	Have sufficient emergency backup generators and supplies such as food available to emergency personnel?

Risk Management, Resources, and Insurance: (for Senior Personnel) Has your Port:	
1.	Conducted a risk assessment process to analyze financial loss exposure for identified hazards and risks?
2.	Determined an acceptable level of risk (or risk tolerance) for various hazards?
3.	Included coverage for costs incurred to prevent further loss in the event of a covered peril? (e.g., mitigation activities)
4.	Included Port facility leases that take into account emergency response and recovery efforts and procedures?
5.	Clearly defined what will happen in the event of damage to facilities in their lease agreements, if an event occurs?
6.	Included a waiver of liability for force majeure conditions contained within your facility lease contracts?
7.	Included a waiver of common carrier status for cargo claims in the event that there is an emergency within your Port facility in its lease contracts?
8.	Provided for a waiver of liability for the replacement of tenant fixtures and improvements in the Port's lease contract with tenants
9.	Are adequate contingency resources available for responding to a disruption?
10.	Are adequate resources available for archiving data and critical records?

V. Emergency Operations During and Post-Disruption

Emergency Operations Does your Port:	
1.	Have an offsite evacuation harbor/port or alternative operation's location site, based on the type of event, where it can continue basic operations?
2.	Have a transportation plan to reach the alternative operation's location that's in accordance with the city's evacuation and re-entrance plans?
3.	Coordinate with the local Emergency Operation's Center and government-based Emergency Operation's Center's efforts?
4.	Have the capability to be self-sufficient without federal or external assistance for at least 3 days?

VI. **Scenario – Consider that there is an impending hurricane due to affect the port in two days.**

a. What actions would be your priority?
b. What other groups would be involved? (ICS positions/types of outside agencies)
c. What key steps would you take to enhance capacity and service of the port ?
d. What steps worked best in previous disruption? What were the lessons learned? What improvements can be made in enhancing recovery?

VII. Overall Resilience: What are the major challenges or obstacles to improving port resilience?