Interdependency of Port Clusters During Regional Disasters

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INTRODUCTION

Puerto Rico contains three major seaports. They are San Juan Port, the Port of Ponce, and the Port of Mayaguez. In 2017, these ports were disrupted by the wind and waves Hurricane Maria brought to the coast of Puerto Rico. Hurricane Maria devastated the island and its 3.4 million residents. This storm registered as a category 4 hurricane that brought 155 mph winds and 23.6 feet of rain. Flooding destroyed homes and left the entire island without power. Hurricane Maria was said to be the most devastating storm to hit Puerto Rico in 80 years. The ports along the coasts of the island suffered severe damage from the rising sea-levels and strong winds making landfill over them.

The performance of maritime transportation systems struggle to remain reliable and resilient during times of disruption. Major disruptions at a port may result from external threats such as storms, terrorist, labor disputes, and oil or hazardous material spills 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 effect the disruption has on the port, its ability to respond to a performance measure such as port capacity, as well as in terms of the duration of the impact on the performance measure.

METHODOLOGY

AIS DATA COLLECTION AND PROCESSING

AIS technology was developed primarily for improving marine safety and maritime domain awareness [4]. The AIS technology uses the VHF radio spectrum to broadcast and receive real-time information concerning vessel identity, dimensions, position, speed, and headings, among other fields. All commercial vessels operating in or bound for U.S. waters are mandated to carry AIS technology by the Maritime Transportation Security Act of 2002 (46 USC 70113, 70114). The U.S. Coast Guard is involved in developing standards for AIS message formatting, and has established an archive of historical AIS data as part of its National Automated Identification System program [5]. The archival AIS data for this study will be obtained from a commercial vendor.

For this study, vessel location information from onboard AIS transmitters will be used to generate average vessel dwell time within the port area of interest and net vessel transits into and out of the port areas of interest. Dwell time is the continuous length of time a vessel spends within the port area or associated regions such as offshore anchorages [1]. This indicates the capability of the port to efficiently handle cargo flows at the terminals and beyond [5]. During a disruptive event, there is a decrease in port performance. Vessels are processed at a slower rate, causing an increase in overall dwell time in the area surrounding the port. The ability of ports to recover from a disruptive event determines their level of resiliency.

PROJECT BACKGROUND

EXISTING RESEARCH

The ability of transportation systems to function when altered by a disruptive event is crucial for maintaining the national security and defense capabilities of the United States, as well as for the efficient supply chain. Many of the existing research on external disruptions to ports have been done on a small scale. Parr et al. created a simulation to generate various scenarios for the evaluation of three case study ports and estimate their resiliency. These simulated case studies were the partial closure of Port Everglades due to flooding, an oil-hazards spill at the Port of New Orleans, and a labor strike at the Port of Long Beach [3].

The contribution of this research is to empirically show how port clusters rely upon each other during disruptive events to increase the overall resiliency of water bourn commerce. The disruptions caused by Hurricane Maria in Puerto Rico, had both short-term and long-term impacts to the affected region. In the short-term, Puerto Rico experienced an inability for freight vessel to access any of the three ports on the island territory, delaying the flow of relief goods. Long-term, the economic impact and the recovery process of this region will likely be affected by the devastating storm.

TIME-DEPENDENT RESILIENCY ANALYSIS

The time-dependent resiliency analysis plots will allow for systematic, objective measures of measuring the resiliency of ports in a cluster. In an increasing service system, network output is positively correlated with service time. These plots will allow the analysis of a port’s productivity before, during, and after a disruptive event to determine their resiliency. A generic time dependent resiliency plot is shown in Figure 1 (a) for an increasing service system and Figure 2 (b) for a decreasing service system.

RESULTS

In general, the results of the research are expected showed the benefits of quantifying resiliency and how the information gained from such analysis can be beneficial when evaluating the impact of disruptive events on regional ports clusters. The quantitative assessment of resiliency provides meaningful context and relevance to port stakeholders which may not be readily apparent at face value. The interdependent nature of maritime systems requires redundancies and therefore the impact of disruptive events must be viewed from a holistic approach. It is not possible to see the entire region’s impact of freight transportation by examining the hindrance of one port. It is necessary to see the forest through the trees and develop methods and means to analyze these networks, systematically.

This research will also show that Automatic Identification System (AIS) data can be utilized to create new methods and metrics for the assessment of resiliency in maritime systems. This research may show, in quantifiable terms, reductions in performance resulting from a simulated disruption. On a broad level, research may represent one of 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 [3].

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