

COMPLEX DISRUPTIONS TO MARINE TRANSPORTATION SYSTEMS

"THERE IS INCREASING CONCERN THAT SIMPLY REPLACING LEGITIMATE DATA WITH MISLEADING DATA WILL BE SUFFICIENT TO SHUT DOWN OPERATIONS OR CAUSE MAJOR DISRUPTIONS."

MAIN

A ship passes below a bridge in Los Angeles. Marine transportation can be disrupted by accidents, attacks, natural disasters, and many other factors





Fred Roberts, Andrew Tucci, and Latha Vijayagopal

Two U.S. Department of Homeland Security University Centers of Excellence, CCICADA at Rutgers University and CREATE at University of Southern California, are collaborating on a framework to understand the causes and consequences of multiple, complex disruptions to maritime trade. The following article provides an overview of that research and invites readers to contact the authors and offer insights into this topic.

In recent years, ports and maritime supply chains have suffered from various disruptions, from a vessel grounding in the Suez Canal to natural disasters, massive shifts in consumer demand and trade activity, port congestion, cyberattacks, COVID-19, and, most troubling, the Russian invasion of Ukraine. Taken on their own, any one of these disruptions would have been a challenge to the marine industry. Taken together, they became 'complex' disruptions with consequences that cascaded beyond the usual suspects of port and vessel operators.

As readers of this journal know, the marine industry is resilient. Bad weather at sea, port accidents and congestion, and all manner of trade and technology challenges are all part of routine operations. Even when the severity of these events precludes normal day to day activity, contingency plans are plucked from the shelves and all hands work to resolve the crisis, find alternatives, and resume normal operations.

This resilience has its limits if the disruption is particularly severe,

if it is novel (like the coronavirus), or the disruptions combine in complex or unexpected ways. The maritime industry has experienced all these circumstances in recent years. Understanding how complex disruptions occur, and how their impacts cascade through an economy, can help us identify supply chain vulnerabilities and identify opportunities to improve.

BACKGROUND AND PURPOSE

Since the beginning of the pandemic the public has been upset about supply chain problems. It is fair to say that plenty of manufacturers, and yes, even some terminal operators and supply chain specialists, have been surprised by the impact and persistence of these disruptions.

A primary goal of our research is to be able to explain to the public and policy makers how various disruptions have combined to impact maritime trade, and how those factors may play out in the future. Equally important, we would like to be able to identify and share

best practices that industry and other maritime stakeholders may use to mitigate future risks.

To date, most research and contingency planning has focused on single-event disruptions – such as an oil spill, natural disaster, or security incident. There has been little analysis of the cascading impacts of multiple disruptions that build on each other in complex ways. This suggests that modeling the impact of multiple disruptions to maritime supply chains can help business leaders, policy makers, and others anticipate, plan for, mitigate, and recover from future disruptions from a multitude of interacting threats, ranging from cyber security to climate change.

MODELING DISRUPTIONS AND SUPPLY CHAINS

Our initial work noted that disruptions could include historic as well as emerging threats, and large and small scale disruptions that, in combination, could lead to significant impacts. The table below provides some examples:

| Natural Disasters | Technological Accidents | Cyber and Extreme Threats | Trade Issues |
|----------------------------|---|---|--|
| hurricanes | oil or chemical spill | cyberattacks to port facility/vessels | tariffs/trade war |
| earthquakes/tsunami | vessel grounding/fire in port/channel | GPS/AIS disruptions | labor/management dispute |
| storm surge/sea level rise | damage to bridges and port infrastructure | sustained regional security threat/incident | specialised marine fuel shortages |
| infectious disease | sustained power outages | nuclear contaminated port, vessel/cargo | truck, chassis, or container shortages |



“BETTER COORDINATION BETWEEN SHIPPERS, VESSELS, AND PORT FACILITY OPERATORS COULD IMPROVE PORT EFFICIENCY... HOWEVER, BUSINESS CONFIDENTIALITY CONCERNS ARE LIMITING PROGRESS IN THIS AREA.”

Any single disruption can vary with severity, duration, location, and other factors. And, of course, not all organisations are equally vulnerable to all disruptions.

Marine trade requires a multitude of players and capabilities, but can be roughly grouped into long distance transit, port operations, and upland activity. Within this inadequate definition falls everything from inter-ocean canals to the local availability of chassis or warehouse space. People are the basis for the entire system. If there is one thing COVID taught us, it is that technology, automation, and infrastructure are useless without skilled people at every step.

When multiple disruptions

coincide to degrade multiple aspects of this system, businesses must devise increasingly complex workarounds. At a certain point, those workarounds reach their limit, and cascading impacts occur.

METHODOLOGY:

We are approaching this work through:

- Literature review of related research
- Interviews with port and vessel operators and other experts
- Studying trade journal and other informed media reports
- Development of models and simulations

ABOVE
Container ship in the Port of Baltimore

This work is leading up to the centerpiece of the research, a detailed description of several complex disruptions in specific ports. In a forum similar to a tabletop exercise, we will discuss the scenarios with various port stakeholders. The purpose of the activity is not to test emergency response actions, but rather to draw out estimates of how the disruptions would impact port and other commercial activity, for how long, and in what ways.

The analysis will focus on the total economic consequences of these threat combinations. We are interested in capturing lessons learned and mitigation practices. The results will feed into a user-friendly modeling tool we are building, based on computable general equilibrium theory, that can aid in identifying cascading impacts of complex multi-vector disruptions.

INITIAL OBSERVATIONS:

While the research is ongoing, we have noted a few early observations:

- Changes in trade activity are a large driver of cascading

impacts. This includes “just in time” inventory, which is shifting to “just in case” for many businesses. Capacity is a challenge, and a single, low-capacity link in a supply chain can make improvements in other areas irrelevant.

- Better coordination between shippers, vessels, and port facility operators could improve port efficiency and technology provides promising information-sharing solutions. However, business confidentiality concerns are limiting progress in this area.
- COVID-19 forced a certain amount of remote work and automation as solutions; however, long-term viability of those strategies remains uncertain.
- The combination of cyber and physical disruptions, particularly in critical areas (such as chokepoints), is a significant risk. Sustained power outages are also a concern, particularly where automation and air quality requirements may limit the ability to return to manual operations at the desired throughput.
- Security complacency may be an issue. For several years, the focus has been on COVID-19 and its impacts, and on issues such as automation and electrification. The ability of some ports and maritime stakeholders to respond to a sustained security threat is uncertain.
- There has been tremendous innovation on specialised low and no-carbon marine fuels, but less attention on how a disruption could impact their availability at critical times.
- With the increasingly complex technologies used in ports and vessels, highly trained labour becomes increasingly important.

- Cyberattacks that compromise data integrity can have a significant impact on operations, even in systems where no direct, kinetic impact is possible. There is increasing concern that simply replacing legitimate data with misleading data will be sufficient to shut down operations or cause major disruptions.
- Undeclared or improperly packaged hazardous materials, including lithium-ion batteries, are a growing concern and could lead to a fire or other incident.

UKRAINE

The Russian invasion of Ukraine has had widespread impacts on maritime trade, including on seafarers. We are closely monitoring these impacts and have already studied in detail the cascading impacts of shortages in grains and minerals/metals from Ukraine and Russia. We will include any relevant observations in our final report.

HOW YOU CAN HELP

If you have opinions, observations, or recommendations related to “complex disruptions” and how the industry can improve its resilience, please contact Dr. Fred Roberts at froberts@dimacs.rutgers.edu. We'd love to talk with you!

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LEFT
Marine transportation requires both new and traditional skills

ABOUT THE ORGANISATION:

CCICADA—The Command, Control and Interoperability Center for Advanced Data Analysis—is a US Department of Homeland Security University Center of Excellence based at Rutgers University that applies multidisciplinary methods of data analysis, modeling, and simulation to support information-driven decisionmaking to address natural and manmade threats to safety and security.

ABOUT THE AUTHORS:

Fred Roberts is Professor of Mathematics at Rutgers University and Director of the CCICADA Center, a U.S. Department of Homeland Security university center of excellence. He has done extensive research on cyber and physical disruptions to the marine transportation system, much of it in collaboration with the U.S. Coast Guard.

Andrew Tucci is a retired U.S. Coast Guard Captain with over 30 years of experience working with the marine industry in security, safety, and environmental risk management.

Latha Vijayagopal is a graduate student of the Rutgers MBS programme and part-time research assistant at CCICADA Center. She has previously worked 17 years for a Fortune 500 company that builds enterprise management software, in their R&D and Technology offices.

“PEOPLE ARE THE BASIS FOR THE ENTIRE SYSTEM.”