CAOE | CENTER FOR ACCELERATING OPERATIONAL EFFICIENCY

A DEPARTMENT OF HOMELAND SECURITY CENTER OF EXCELLENCE

Ports and Waterways Safety Board of Inquiry

Modeling the Impact of Complex, Multi-Vector Disruptions to the Marine Transportation System (MCAT)

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Project Overview

- Since 2022, we have been researching how “complex disruptions” can impact the MTS and supply chains.
- While the MTS is resilient, multiple disruptions can have unexpected impacts. We know little about how these disruptions interact and how they impact downstream businesses.
- Risk Assessments tend to focus on single vector disruptions and overlook the consequences to non-MTS stakeholders.
- Modeling multiple vector disruptions and identifying potential countermeasures can help policy makers, business leaders, and others anticipate, plan for, mitigate, recover from them.

The Ever Given wedged in the Suez Canal, blocking traffic in both directions. Credit: Contains modified Copernicus Sentinel data 2021, CC BY 2.0, via Wikimedia Commons

Complex disruption: COVID + ship blocking Suez Canal

A Project Involving Three DHS University Centers of Excellence

- **CCICADA** (Command, Control, and Interoperability Center for Advanced Data Analysis) run by Rutgers University
- **CREATE** (Center for Risk and Economic Analysis of Threats and Emergencies) run by University of Southern California
- **CAOE** (Center for Accelerating Operational Efficiency) run by Arizona State University

Our Methodology

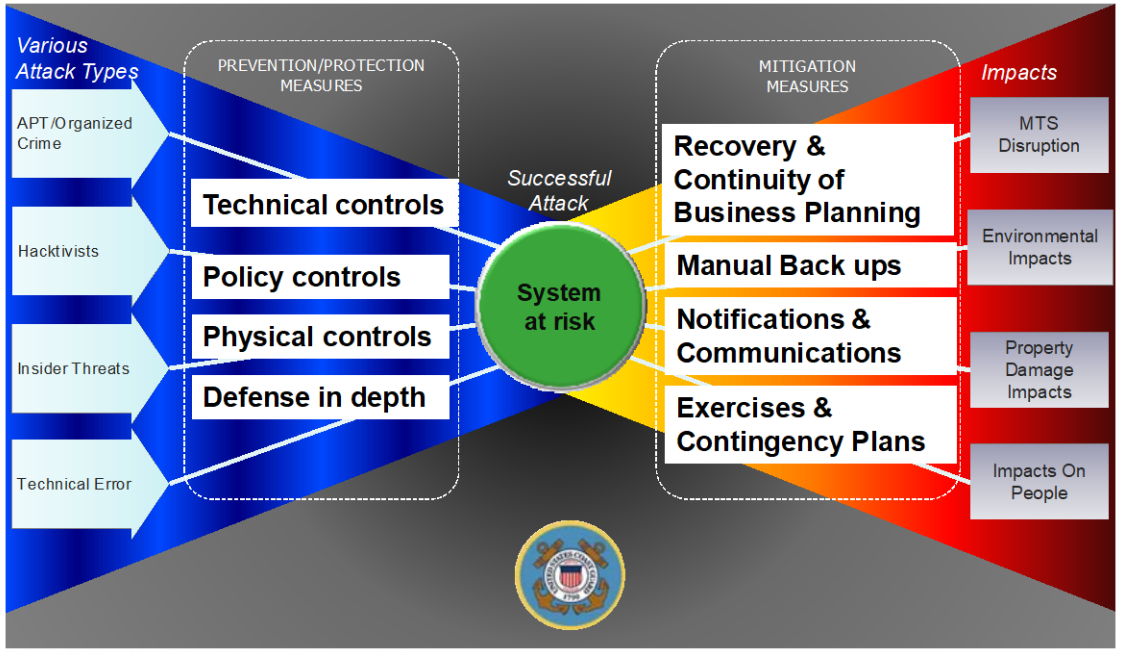
- Work with Advisory Board members, Coast Guard partners, the private sector, and others to develop plausible, complex MTS disruptions
  - current database close to 40 examples
- Understand the role of background conditions and other factors
- Identify key port/supply chain inputs (e.g. power, comms, labor)
- Identify high risk combinations
- Ask stakeholders about consequences and resilience tactics
- Conduct detailed economic analysis on select scenarios (MCAT)
- Consider economic consequences beyond the MTS
- Identify promising countermeasures

Risk Assessment

Standard approach:

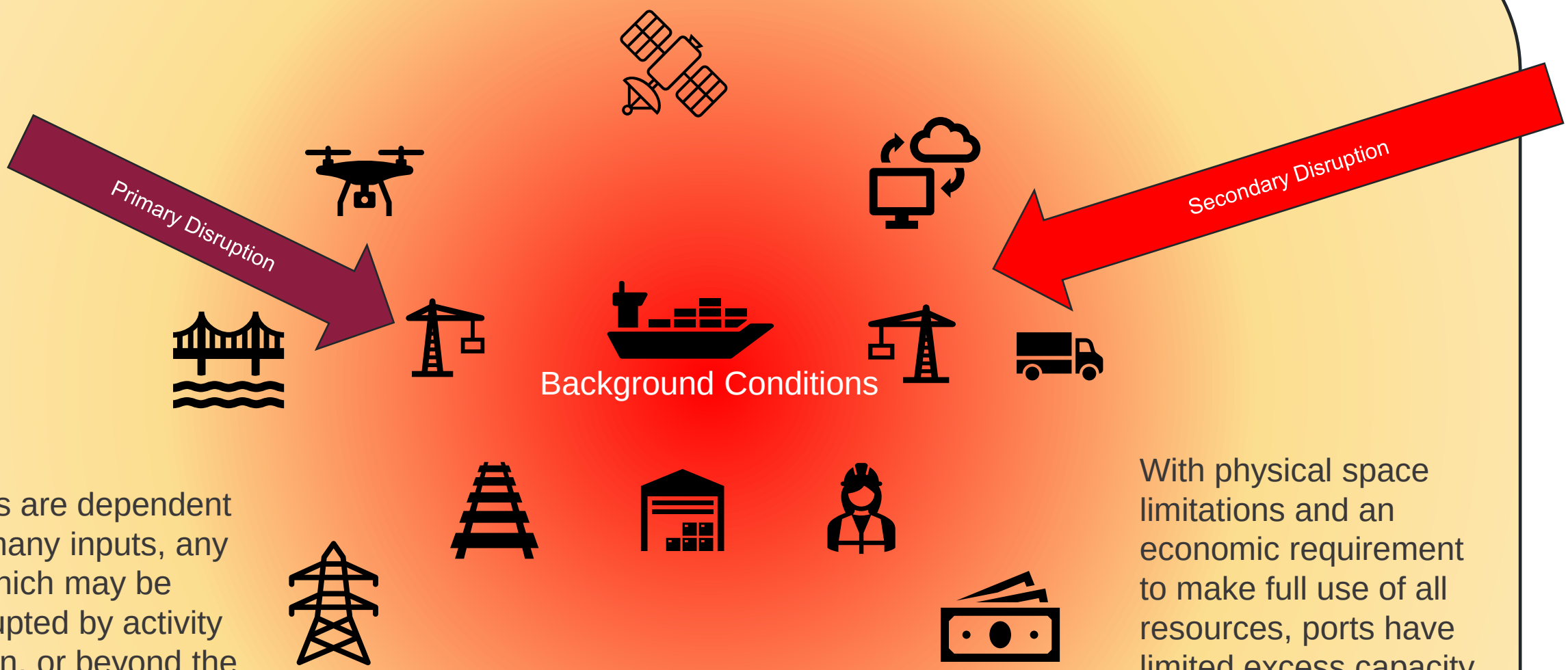
- Risk = probability (single vector) x consequences
- Risk = threat x vulnerability x consequences
- Focus is usually on a single event, well recognized MTS scenarios, with an assumption of neutral background conditions, not necessarily worst case. (exception, OPA 90)

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	specialized marine fuel shortages
infectious disease	sustained power outages	NCBR contaminated port, vessel/cargo	truck, chassis, or container shortages



Our approach, risk must consider:

- Multiple vectors
- Vectors from outside the MTS
- Unexpected and rare events
- Adverse background conditions
- Cascading consequences



Ports are dependent on many inputs, any of which may be disrupted by activity within, or beyond the MTS.

Ports exist to serve upland customers. Economic consequences will always extend beyond port boundaries and persist long after normal port activity resumes.

With physical space limitations and an economic requirement to make full use of all resources, ports have limited excess capacity or redundancies.

Complex Disruption Example: NY/NJ (KVK) Scenario

Background Scenario: Busy season, and a combination of truck driver, chassis, and warehouse shortages has increased terminal dwell time of containers in the NY/NJ area.

Initial Disruption: Container ship (or Ro-Ro) fire blocks the KVK.

Cargo will include HAZMAT; tug may not be able to prevent grounding.

4 Days to extinguish fire; large public safety impact due to smoke.

4 more days of limited traffic.

Complex Disruption Example: NY/NJ (KVK) Scenario

Secondary Disruption: Cyber attack on terminal operating system

NotPetya-like attack on one NJ terminal disables TOS; targeted terminal shut down (*for NotPetya, 7-10 days!)*

Indicators of compromise – and rumors – lead the Coast Guard, CISA, and industry to slow cargo ops at other area terminals as specialists examine those systems to ensure they are safe.

Backups grow exponentially
Economic impact would be higher if freight/ container rates were high.

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Scenario Categories	Vessel Fire and Tow Operations				Cyber Attack & 1 Way Ops		1 Way Ops		Normal Ops
Container	80%	80%	80%	80%	87.5%	75%	75%	40%	0%
Bulk Commodity	100%	100%	100%	100%	100%	100%	50%	50%	0%
Automobile	80%	80%	80%	80%	100%	80%	40%	40%	0%
Cruise	0%	0%	0%	0%	50%	0%	0%	0%	0%
Petroleum/Oils	0%	0%	0%	0%	0%	0%	0%	0%	0%

NY/NJ (KVK) Scenario

- Detailed input for KVK disruption from **USCG Sector NY** and **Port Authority of NY/NJ.**
- USCG planned an exercise on just such a blockage and we were included.
- Port Authority convened a panel of SMEs to help us develop the scenario.

Low Water on the Mississippi River

Background: Increasing demand worldwide for food as a result of Ukraine; already high demand for corn and fertilizer due to ethanol and other needs

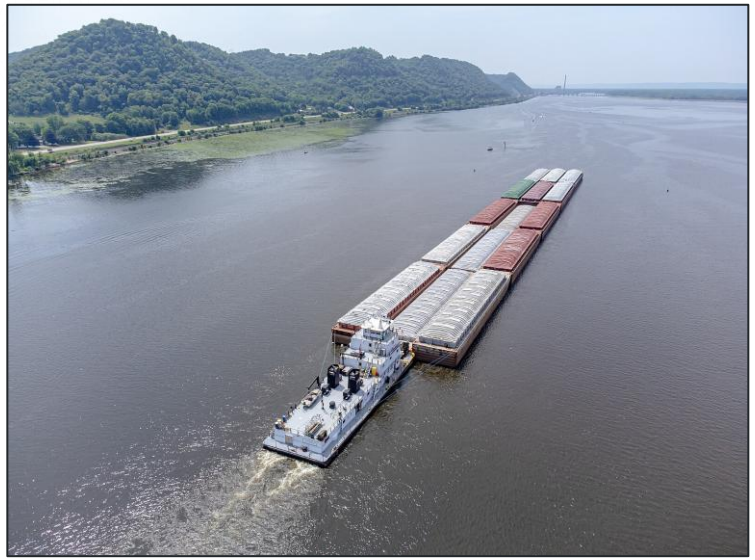
Initial Disruption: Record low water from Memphis to New Orleans; barge trains are shorter; grain, fertilizer, and oil barge loads are lighter

Secondary disruption: Lock and dam failure to Lock 27 (near St. Louis) just before Spring planting

Exacerbating Events: Exacerbated by **reductions of fertilizer import at Port of New Orleans**

Barges and Fertilizer

- **Low water led to barges becoming stranded in mud and sand**
  - Necessitating **lighter barge loads, shorter barge trains** and the implementation of one-way traffic in certain river sections
  - At the low water level of October 2022, approximately 2,000 barges were backed up along the river waiting passage
  - Consequently, **barge transportation rates soared to more than 400% above average**
  - **Barge labor productivity** (the work or output achieved by a unit of labor within a specific timeframe) **dropped significantly**



credit: Wikimedia commons, Wikideas1

Mississippi River Scenario

MARAD Leaders suggested this scenario

AWO, US Army Corps of Engineers, and USCG input

- Summer 2022 had **Record low water**
  - A trip between Cairo Illinois to New Orleans that normally takes between 13 and 14 days, took almost 27 days during that time
  - Barges that normally get loaded up to 12 ft or more, were down to 9ft causing a severe shrinking of towing capacity leading to a reduction of over 50%
- Then summer of 2023 had a repeat of really low water
- **A good test of our MCAT model** - leading to a detailed economic analysis of the resulting impacts on the fertilizer and grain markets
- Results presented to Senate Budget Committee hearing on effect of climate change on the supply chain
- Consider a similar scenario for the Panama Canal – drought plus infrastructure damage would have tremendous consequences for the U.S.!

LA/LB Complex Disruption “West Coast Whammy”

- **Background Conditions**: Labor Strike
- **Initial Disruption**: Power outage due to wildfires
- **Secondary Disruption**: Sustained MARSEC 2 due to bomb in container, ongoing threats

- Strike and power outage create significant backlogs
- Security incident is not quickly resolved
- Agencies and industry struggle to meet screening and other security requirements
- Labor (and management) is reluctant to return to work
- **Port is reliant on semi-autonomous cranes, cargo equipment, rail, and other infrastructure**

- Scenario developed through strong collaboration with security team at Port of LB and USCG Sec LA/LB.
- Reflects their concerns.

LA/LB Complex Disruption "West Coast Whammy"

COVID experience showed the impact of a surge in demand + labor shortage

Table 2. Base Case LA/LB Import Disruption Economic Impacts – Without Resilience (quantity and price shocks combined for all 3 disruptions)

Macro Variable	LA Metro	SF Metro	RoCalifornia	RoUS	National
Real GDP (millions of 2023$)	-4,084.5	41.9	- 330.1	4,073.2	-297.6
Real GDP (% change)	-0.373	0.007	-0.043	0.024	-0.002
ExpVol (% change)	-0.391	-0.380	-0.412	-0.380	-0.382
ImpVolUsed (% change)	-4.713	0.025	-1.158	0.059	-0.250
ImpsLanded (% change)	-27.822	2.222	2.472	1.390	-0.256
GDPPI (% change)	0.208	0.200	0.262	0.213	0.215
CPI (% change)	0.478	0.200	0.280	0.203	0.221
ImpsLandedPI (% change)	5.436	n.a.	n.a	n.a.	0.282

Our analysis estimates impact on the economy of several regions, and overall GDP

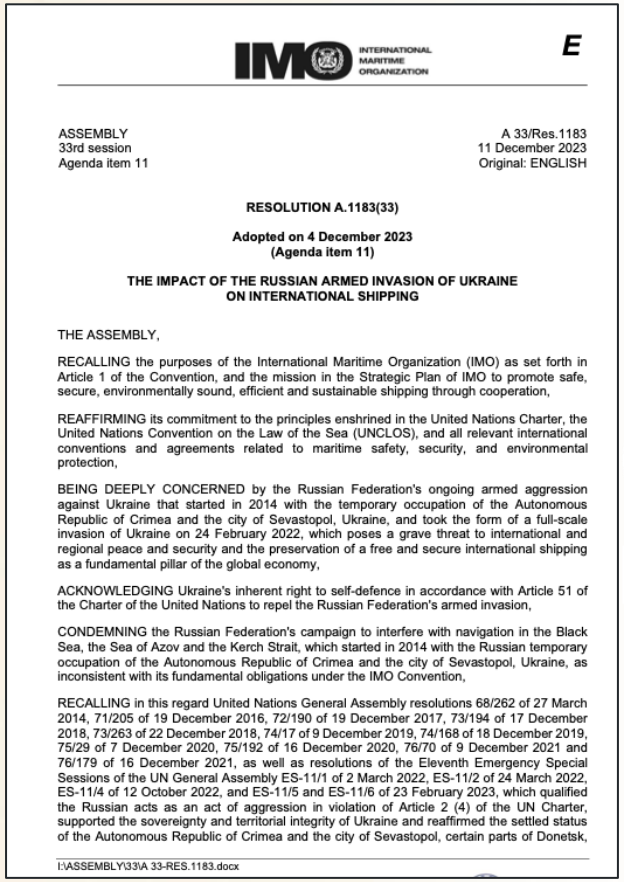
Table 3. Base Case Decomposition of Disruption Economic Impacts (percent change in Annual GDP)

Disruption	LA Metro	SF Metro	RoCalifornia	RoUS	National
Strike	-0.036	-0.001	-0.008	0.001	-0.0011
Power Outage	-0.025	-0.001	-0.002	0.001	-0.0008
MARSEC Incident	-0.085	-0.001	-0.009	0.004	-0.0006
Complex Event Summation	-0.146	-0.003	-0.019	0.006	-0.0025
Complex Event Combined	-0.373	0.007	-0.043	0.024	-0.0020

West Coast Scenario Results

- **Base Case Impacts**:
  - LA Metro area economy: -$4.1 billion (0.373% decrease in annual GDP)
  - US economy: -$300 million (SF and Rest of US picks up much of the slack)
- **Individual Threat Impacts: Comparing Impacts of the Three Disruptions:**
  - MARSEC incident has largest effect on LA Metro economy of all three
  - Strike has largest effect on US economy of all three
  - Substantial negative synergies stemming from ship congestion
- **Sensitivity Tests:**
  - Avoidance behavior (MARSEC) leads to LA Metro impacts 13% higher
  - Results very sensitive to lower and upper bound changes in basic assumptions
- **Resilience Analysis: What are Effective Responses?:**
  - Five resilience tactics can reduce losses for LA Metro by 72%
  - Production recapture, inventories, and ship-rerouting have strongest effects

Ukraine War and its Impacts



IMO INTERNATIONAL MARITIME ORGANIZATION

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ASSEMBLY
33rd session
Agenda item 11

A 33/Res.1183
11 December 2023
Original: ENGLISH

RESOLUTION A.1183(33)

Adopted on 4 December 2023
(Agenda item 11)

THE IMPACT OF THE RUSSIAN ARMED INVASION OF UKRAINE ON INTERNATIONAL SHIPPING

THE ASSEMBLY,

RECALLING the purposes of the International Maritime Organization (IMO) as set forth in Article 1 of the Convention, and the mission in the Strategic Plan of IMO to promote safe, secure, environmentally sound, efficient and sustainable shipping through cooperation,

REAFFIRMING its commitment to the principles enshrined in the United Nations Charter, the United Nations Convention on the Law of the Sea (UNCLOS), and all relevant international conventions and agreements related to maritime safety, security, and environmental protection,

BEING DEEPLY CONCERNED by the Russian Federation's ongoing armed aggression against Ukraine that started in 2014 with the temporary occupation of the Autonomous Republic of Crimea and the city of Sevastopol, Ukraine, and took the form of a full-scale invasion of Ukraine on 24 February 2022, which poses a grave threat to international and regional peace and security and the preservation of a free and secure international shipping as a fundamental pillar of the global economy,

ACKNOWLEDGING Ukraine's inherent right to self-defence in accordance with Article 51 of the Charter of the United Nations to repel the Russian Federation's armed invasion,

CONDEMNING the Russian Federation's campaign to interfere with navigation in the Black Sea, the Sea of Azov and the Kerch Strait, which started in 2014 with the Russian temporary occupation of the Autonomous Republic of Crimea and the city of Sevastopol, Ukraine, as inconsistent with its fundamental obligations under the IMO Convention,

RECALLING in this regard United Nations General Assembly resolutions 68/262 of 27 March 2014, 71/205 of 19 December 2016, 72/190 of 19 December 2017, 73/194 of 17 December 2018, 73/263 of 22 December 2018, 74/17 of 9 December 2019, 74/168 of 18 December 2019, 75/29 of 7 December 2020, 75/192 of 16 December 2020, 76/70 of 9 December 2021 and 76/179 of 16 December 2021, as well as resolutions of the Eleventh Emergency Special Sessions of the UN General Assembly ES-11/1 of 2 March 2022, ES-11/2 of 24 March 2022, ES-11/4 of 12 October 2022, and ES-11/5 and ES-11/6 of 23 February 2023, which qualified the Russian acts as an act of aggression in violation of Article 2 (4) of the UN Charter, supported the sovereignty and territorial integrity of Ukraine and reaffirmed the settled status of the Autonomous Republic of Crimea and the city of Sevastopol, certain parts of Donetsk,

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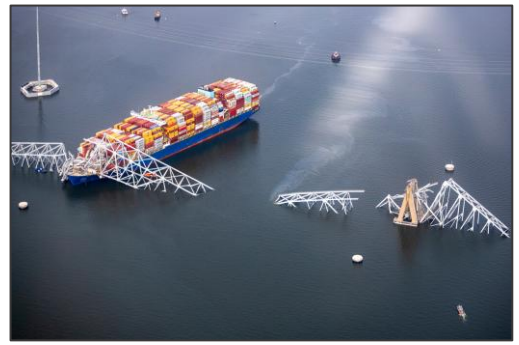
- Seafarers killed, injured, and stranded
- Changes in U.S. energy markets
- Large increase in dark fleet shipping
- Global safety and security impacts
- Regional food and energy shortages
- Attacks on maritime infrastructure

Ship-to-ship transfers to evade sanctions

Unfortunately, Our Imagined Scenarios

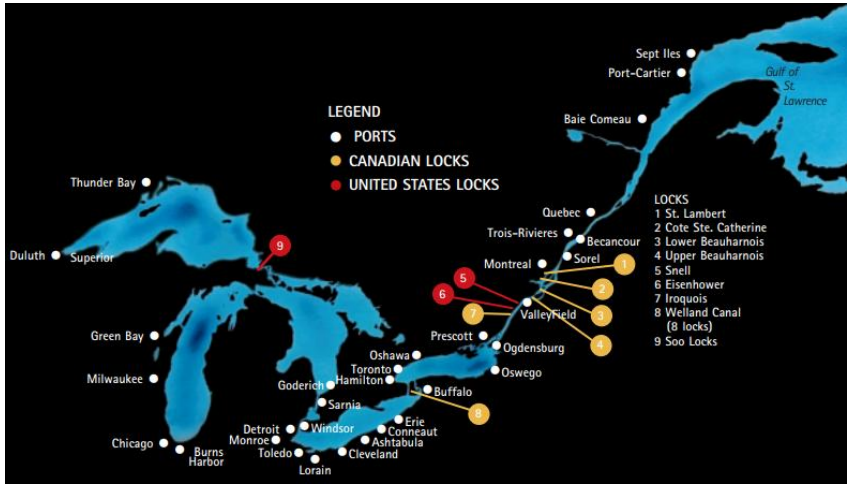
...keep happening for real

- ✓Our team was invited to plan and participate in the CMTS sponsored exercise in September 2023 with the loss of the FSK Bridge as the scenario. The exercise did not address prevention.
  - Technically, not a complex incident with several disruptions.
  - A single incident with complex, cascading impacts.
- ✓A major ship fire near the KVK also occurred shortly after we had described our KVK scenario and participated in a SECNY exercise.
- ✓Low water continues to slow barge traffic on the LMR.
- ✓Russian Dark Fleet activity continues to grow.



Oil tanker CERES on fire after a collision

Great Lakes Issues
(current focus area)



- Growing container trade
- Soo Locks Construction
- St. Lawrence Seaway
- CMTS Exercise (Cleveland)
- D9 Resilience Exercise
- Ice breaking capacity

Smart Ports Challenges
(current focus area)

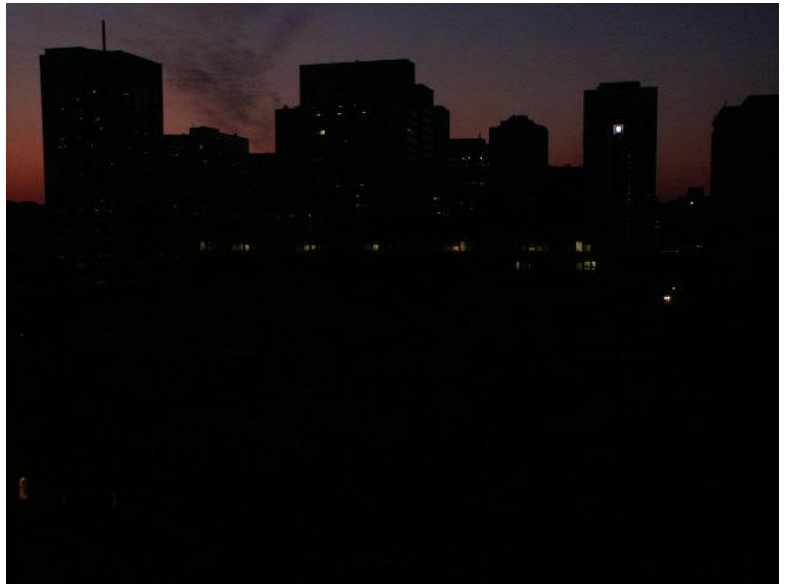
Definition: “Smart port” = marine terminal or port complex using some combination of AI, IoT, digital twins, big data, blockchain, 5G, and automation, in an integrated manner to improve resilience, efficiency, and safety. ***Not just robots!***

Smart ports may be more efficient, but they are likely vulnerable to disruptions such as cyber attacks, power loss, sabotage, and climate change.
Are we prepared?

A Selection of Observations

- 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.



credit Commons.wikimedia commons
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A Selection of Observations

- Security complacency may be an issue. For several years, the focus has been on COVID and its impacts, and on issues such as automation and electrification.
- The ability of some ports and maritime stakeholders to conduct efficient MTS activity during a sustained security threat is uncertain. A security threat could therefore lead to greater than expected disruptions.

Image credit: Wikimedia Commons

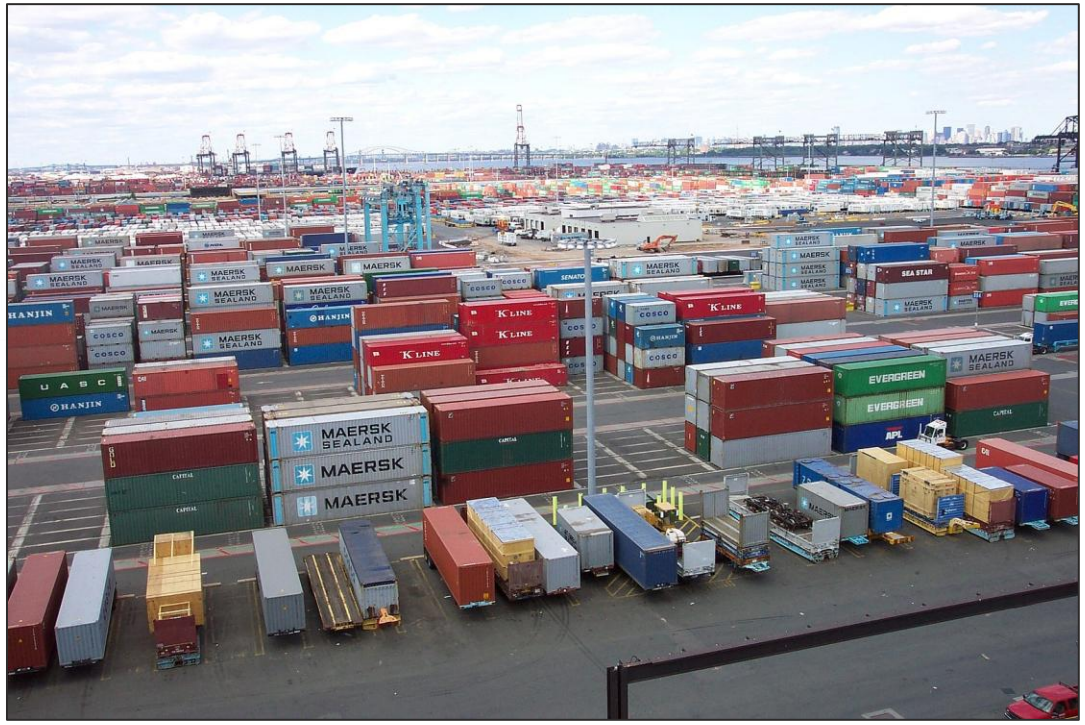
A Selection of Observations

- There has been tremendous innovation on specialized low and no-carbon marine fuels, but less attention on how to respond to a salvage or firefighting incident, or a lack of their availability at critical times.
- 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 creating the perception of a data integrity problem could be sufficient to shut down operations or cause major disruptions.

Credit: Wikimedia commons, Tavo Romann no changes made

A Selection of Observations

- The only way to expand terminal capacity in ports like New York is vertical, meaning higher stacks of containers.
- But higher has its limits, is a poor use of space, and adds risks during wind events and routine handling.
- Ports are at capacity!
- How to enhance capacity?



Container terminal, Port of Elizabeth, credit: Wikimedia Commons, NOAA

Final thoughts:

- MTS supply chain disruptions do not occur in a vacuum, do not begin or end at the port, and do not occur in otherwise ideal circumstances.
- Infrastructure includes everything from concrete to fiber optic cables on the seabed. Infrastructure is increasingly vulnerable to accidents, natural disasters, and malicious actors.
- One of our favorite questions is “what keeps you up at night?” For any system, someone knows where the key failure points are. Don’t be afraid to talk about them just because no single agency or organization can fix it.

Final thoughts:

- For various reasons, exercises and contingency plans tend to focus on single (but still challenging) scenarios and immediate response actions. They are also often silent or vague about causes.
- Consider adding a “minority report” to response exercises that would identify worst case conditions, additional threat vectors, critical kill points, and what actions might prevent their occurrence or greatly reduce their impact.
- Stakeholder outreach beyond the usual suspects is key to understanding risk and developing accurate measures of cascading consequences.
- People must remain the focus of all of our efforts.

Thank you!

Please contact Fred Roberts or Adam Rose or Andrew Tucci at froberts@dimacs.rutgers.edu or adamzros@usc.edu or andrew.e.tucci42@gmail.com for questions or other feedback.

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The material in this presentation is based upon work supported by the U.S. Department of Homeland Security under Grant Award Number, 17STQAC00001-08-01.