Supply Chain Adaptation to Persistent Disruption

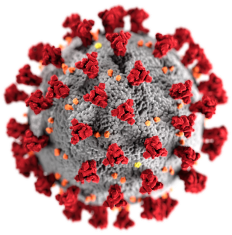
MIT Manufacturing Conference
March 16, 2022

Jarrod Goentzel

MIT Center for Transportation & Logistics

Persistent pandemic disruptions

Initial COVID-19 disruptions



- Non Pharmaceutical Interventions (NPIs)
  - Dynamic and distinct restrictions made business planning difficult
  - Delays as the operating environment due to disruption and safety adaptation
- Absenteeism
  - Directly from the disease
  - Indirectly from safety concerns, family support, etc.

Essential workers

GUIDANCE ON THE ESSENTIAL CRITICAL INFRASTRUCTURE WORKFORCE

Original release date: March 19, 2020 | Last revised: April 24, 2020

CISA's Identifying Critical Infrastructure During COVID-19 guidance and accompanying list are intended to support state, local, and industry partners in identifying the critical infrastructure sectors and the essential workers.

This document gives guidance to state, local, tribal, and territorial jurisdictions and the private sector on defining essential critical infrastructure workers. Promoting the ability of such workers to continue to work during periods of community restriction, access management, social distancing, or closure orders/directives is crucial to community resilience and continuity of essential functions.

CISA issued the guidance originally on March 19 and has continued to update it based on feedback from the Critical Infrastructure community. The most recent update on April 17, 2020, clarifies the description of a small number of essential services and functions in the list.

If you have feedback or additional questions, please reach out to: CISA.CAT@cisa.dhs.gov

Taxonomy Topics: Infrastructure Security

Attachment

Version 3.0 - CISA's Guidance on Essential Critical Infrastructure Workers	796.49 KB
Ver 3.0 - Guía sobre la Fuerza de Trabajo Esencial de Infraestructura Crítica	607.88 KB
Ver 3.0 - Lignes directrices sur les travailleurs essentiels des infrastructures critiques	676.51 KB

Supply chain resilience for state and local government leaders (March 18, 2020)

1. **Expand the definition of essential businesses to the upstream supply chain.** A grocery retailer relies on a chain of supply nodes (e.g. warehouse/DC, manufacturing) which may be owned by distinct businesses in non-targeted sectors (e.g. third party logistics providers or 3PLs). They must remain open even if operating in a containment zone.
2. **Expand the definition of essential businesses to include essential workers.** Truck drivers are often employed by carriers and not retailers or manufacturers. Service technicians who support safe and resilient facilities are often outsourced. These workers also have a special responsibility to maintain a normal work schedule.
3. **Provide for the safety of these essential workers.** The supply chain comprises a variety of workplace environments (e.g., stores, warehouses, truckstops) and transactions (e.g. truck loading/unloading, retail checkout, home delivery). Employers are struggling to adapt healthcare workplace standards to these varied work environments. These essential workers may also require priority for testing to preserve safe operations.
4. **Coordinate public messaging with grocery retailers and pharmacies.** Communities with confidence in "normal" operations for grocery stores and pharmacies in China and Italy tended to be more cooperative in quarantine restrictions. Coordinated messaging also facilitates critical feedback in providing support to essential retailers.
5. **Where possible implement mandatory shutdowns and containment zones in a precision-targeted way.** Precision-targeting involving areas of less than nine square miles, for example, allows demand and supply networks to adapt.
6. **Monitor and preserve freight transportation.** Freight movement is the backbone for safe and speedy resupply of medical facilities, grocery stores, pharmacies, and other community supply points. Delays in accessing restricted areas directly reduce overall transportation capacity.
7. **Be prepared for fatigue in supply chains**. Demand and supply networks will degrade as containment zones are maintained over time. In China, the preexisting volume and velocity seemed to persist for about two weeks until increasing fragmentation incrementally depleted flows. U.S. freight flows continue to be robust and effective, but increasing restrictive measures can degrade network health by a thousand cuts.
8. **Learn from South Korean best practices in detailed transparency for confirmed cases and especially clusters.** Transparency is the foundation for differentiating restrictive policies and procedures. Business planning is greatly enhanced with open-source geospatial tracking.
9. **As testing capacity increases the evidence base for community spread, prepare for targeted reopening of business.** In most of China -- outside the Hubei epicenter -- the most rigorous restrictions began to be lifted after four weeks. Contingency planning for strategic and tactical options should be prepared early.
10. **Offer early consultations with private sector stakeholders regarding restriction lifting.** Early shifts in business planning away from worst case scenarios will accelerate economic recovery.

Essential workers

https://www.osha.gov/SLTC/covid-19/news_updates.html
as of May 10, 2020

Alerts

- COVID-19 Guidance for Restaurants & Beverage Vendors Offering Takeout or Curbside Pickup (Spanish). (May 1, 2020).
- COVID-19 Guidance for the Construction Workforce (Spanish). (April 21, 2020).
- COVID-19 Guidance for the Manufacturing Industry Workforce (Spanish). (April 16, 2020).
- COVID-19 Guidance for the Package Delivery Workforce (Spanish). (April 13, 2020).
- COVID-19 Guidance for Retail Workers (Spanish). (April 8, 2020).
- Prevent Worker Exposure to Coronavirus (COVID-19) (Spanish). (March 2020).

Other Guidance

- Joint OSHA-CDC guidance: Meat and Poultry Processing Workers and Employers (Spanish). (April 26, 2020).

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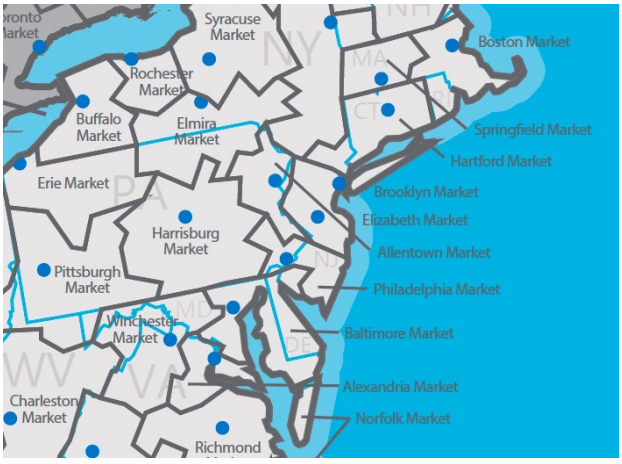
Jurisdictional requirements



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CDC Statement on Self-Quarantine Guidance for Greater New York City Transportation and Delivery Workers

Media Statement

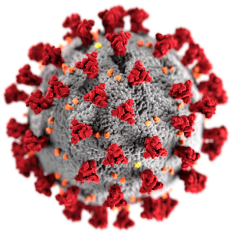
For Immediate Release: Thursday, March 26, 2020
Contact: Media Relations
(404) 639-3286

When we issued the self-quarantining guidance for greater New York City residents leaving this area, it was out of an abundance of caution to help protect U.S. areas with lower levels of COVID-19 spread. In line with our recommendations for other essential critical infrastructure workers, this guidance does not apply to critical transportation and delivery workers who are desperately needed for New York residents to continue their daily lives and respond to the COVID-19 outbreak.

Truck drivers and other people driving into the city to deliver needed supplies should stay in their vehicles as much as possible as supplies are loaded and unloaded, avoid being within 6 feet of others as much as possible when they exit their vehicles, and move to electronic receipts if possible. If these drivers need to spend the night in the greater New York City area, they should stay in their hotel rooms or sleeper cab, when available, to the extent possible and continue to practice social distancing. Drivers who take these precautions should not need to self-quarantine when they leave the greater New York area, unless self-quarantine is recommended by state or local officials for all residents in the areas where they live.

Truck drivers and other workers who obtain or deliver needed supplies who live in the greater New York area may continue to work both within and outside of the greater New York area but should stay at home and practice social distancing according to instructions of state and local officials when they are not working. While they are working either within or outside of the greater New

Initial COVID-19 disruptions



- Non Pharmaceutical Interventions (NPIs)
  - Dynamic and distinct restrictions made business planning difficult
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- Absenteeism
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- Demand volatility
  - Surges for essential businesses
  - Halts for non-essential businesses
- Supply volatility
  - Global supply chain disruptions with cascading effects
  - Poor understanding of supply network operating conditions made business planning difficult

Thankfully pandemics do not damage infrastructure or disrupt communications. In fact, the lack of traffic was great for freight movement.

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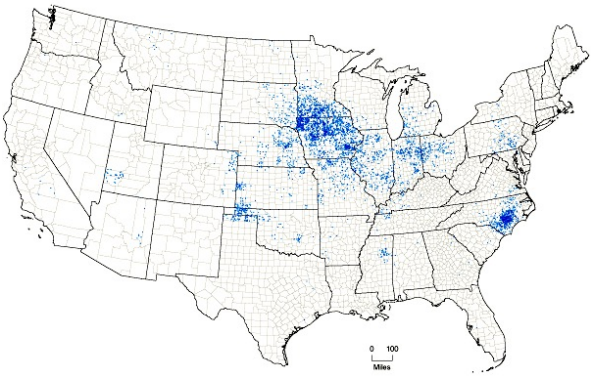
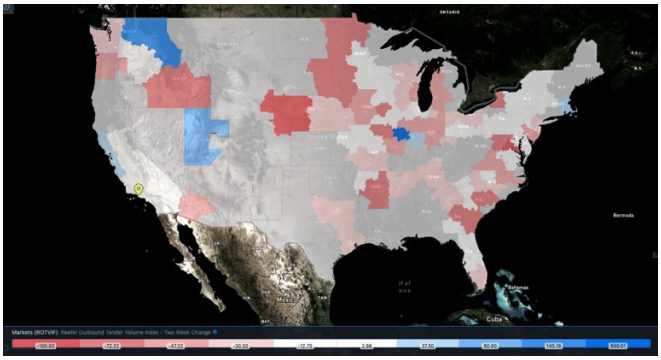
Truckload freight data reveal supply chain dynamics



Hogs and Pigs Inventory (2017 U.S. Census of Agriculture)



Two Week Change in Outbound Reefer Tender Volume Index as of April 24, 2020 (FreightWaves)

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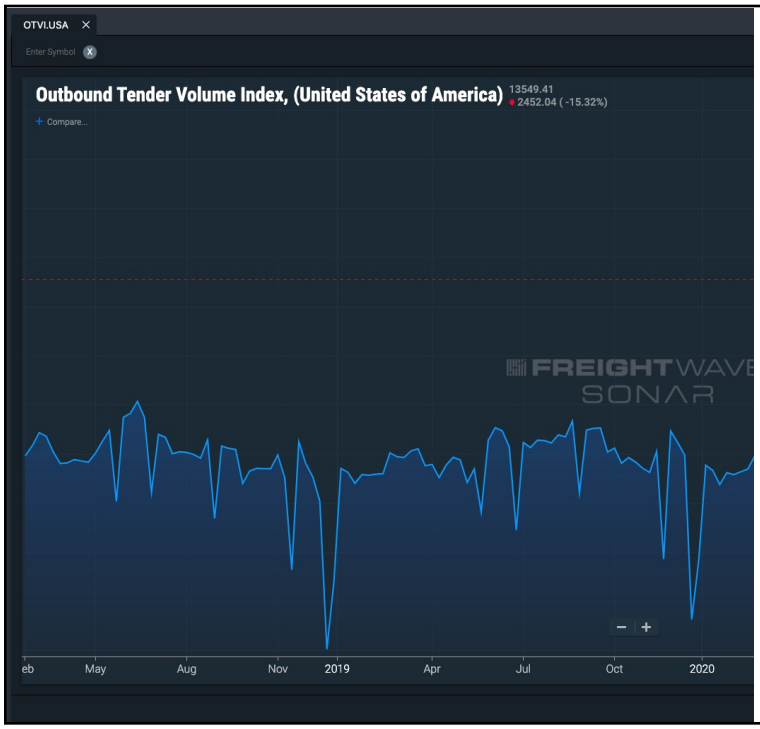


What happened in March 2020?

Jarrod Goentzel (ctl.mit.edu/goentzel)

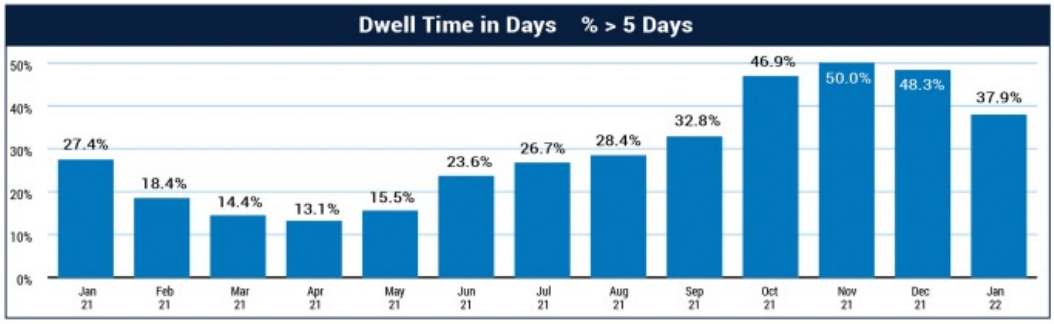
What happened in April 2020?

Jarrod Goentzel (ctl.mit.edu/goentzel)

What happened next?

Jarrod Goentzel (ctl.mit.edu/goentzel)

Persistent disruption



San Pedro Bay (Los Angeles and Long Beach) Dwell Time

Source: https://www.pmsaship.com/wp-content/uploads/2022/02/West-Coast-Trade-Report-February-2022.pdf

Persistent demand pressure

Source: https://fred.stlouisfed.org/series/PCEDG

Persistent demand pressure

Source: https://fred.stlouisfed.org/series/PCEND

Persistent disruption and resilience

- Supply chain disruption has persisted
  - Multiple Covid-19 waves
  - Compounding events (e.g., hurricanes, Texas freeze, Colonial Pipeline cyberattack)
  - Underlying demand pressure
  - Revealing bottlenecks in “optimized networks”
- Increased focus on supply chain resilience
  - Actors traditionally take a “hold your breath” approach to disruption / acute disequilibrium
  - Potential for chronic disequilibrium as social (labor), environmental (extreme weather, regulation), and political (trade regulation, conflict) stresses increase
  - Need to complement supply chain optimization with system adaptation

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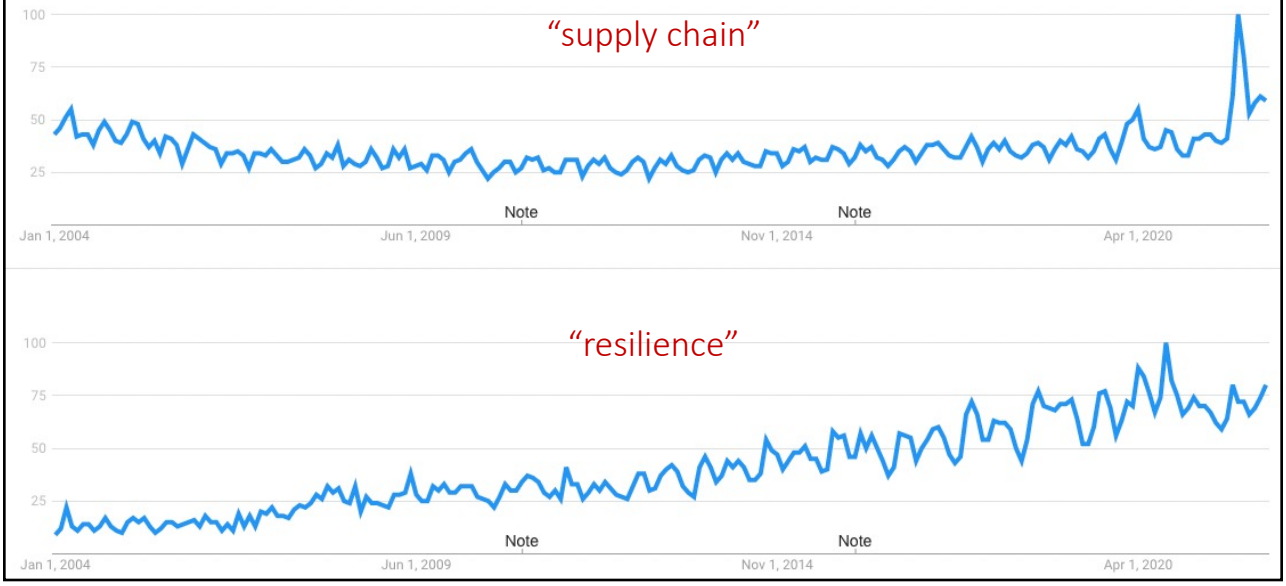
Increased focus on supply chain resilience

Google Trends



Google Trends

"supply chain resilience"

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Federal government employees are included in the Google trend data

- Seven agency reports:
  - Department of Defense
  - Department of Homeland Security
  - Department of Commerce
  - Department of Energy
  - Department of Agriculture
  - Department of Transportation
  - Department of Health and Human Services
- The OMB will issue a new Buy American rule to create a new category products eligible for enhanced price preferences
- HHS will fully establish a Defense Production Act (DPA) program to build and expand the health resources industrial base

THE WHITE HOUSE

BRIEFING ROOM

The Biden-Harris Plan to Revitalize American Manufacturing and Secure Critical Supply Chains in 2022

FEBRUARY 24, 2022 • STATEMENTS AND RELEASES

Release of Historic Industrial Base Reports by Seven Federal Agencies Caps Off a Year of Action Fortifying America's Supply Chains

One year ago, President Biden signed Executive Order 14017 directing an all-of-government approach to assessing vulnerabilities in – and strengthening the resilience of – the United States' critical supply chains. Within six months of taking office, the Administration completed a comprehensive review of the supply chains for four critical

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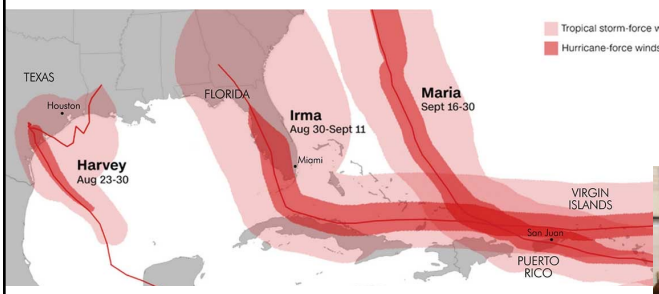
MIT roundtable on supply chain resilience (December 2017)



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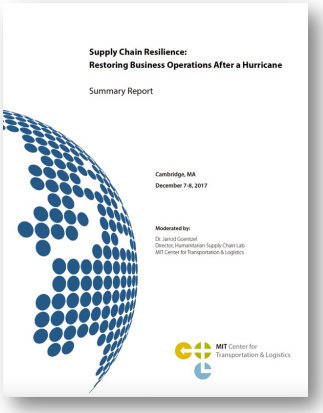
Source: Goentzel, Windle, Meyer, and Meyer (2018). *Supply Chain Resilience: Restoring Business Operations After a Hurricane*. Roundtable Report, MIT Center for Transportation & Logistics. Retrieved from https://ctl.mit.edu/resilience-operations-hurricane

MIT roundtable on supply chain resilience (December 2017)

- **The fragility of optimized networks**. The three hurricanes disrupted flows in supply chains more so than they damaged supply. Networks optimized to maximize efficiency normally cannot adapt easily during a crisis.
- **Deep coupling of human and technological systems**. Without drivers, critical commodities like food and water cannot be distributed. And yet, without food and water, critical employees such as drivers and workers across the supply chain will need to address their family needs above their role in moving goods.
- **The potential cascading effects of supply chain failures**. Many contingencies that lead to cascading effects are hidden during normal operations and are only realized during crisis.



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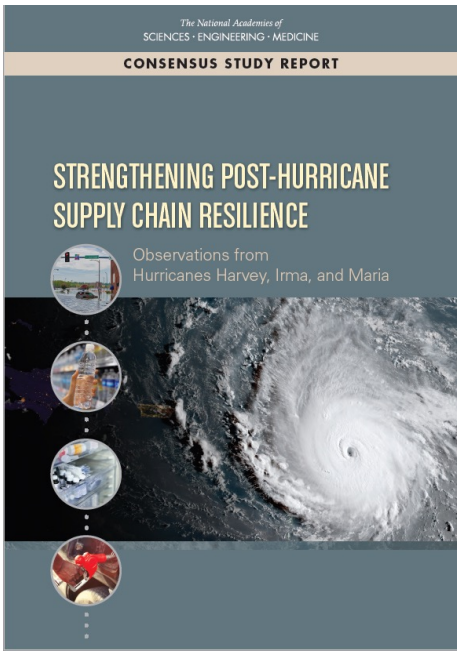
Source: Goentzel, Windle, Meyer, and Meyer (2018). *Supply Chain Resilience: Restoring Business Operations After a Hurricane*. Roundtable Report, MIT Center for Transportation & Logistics. Retrieved from https://ctl.mit.edu/resilience-operations-hurricane

2017 hurricane experiences continue to resonate

"A key first step to resilience is in mapping critical supply chains and critical infrastructure to understand where critical goods (and their essential ingredients) come from and how they might move down the chain…part of this mapping entails measuring the system's conveyance capacity such as tractors, trailers, containers (of various sizes), and compatible chassis. Baseline measurements of logistics activity during normal times provide both a benchmark for recovery and an approximate indicator of likely capacity in a crisis"

MIT Center for Transportation & Logistics

Source: Goentzel, Windle, Meyer, and Meyer (2018). *Supply Chain Resilience: Restoring Business Operations After a Hurricane*. Roundtable Report, MIT Center for Transportation & Logistics. Retrieved from https://ctl.mit.edu/resilience-operations-hurricane



The Committee's Task

Study supply chain strengths and vulnerabilities

For key lessons learned and observations

In areas affected by 2017 Hurricanes

Provide options and recommendations for distribution of key commodities and restoration of utilities applicable to public and private sectors

National Academies of Sciences, Engineering, and Medicine (2020). *Strengthening Post-Hurricane Supply Chain Resilience: Observations from Hurricanes Harvey, Irma, and Maria*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25490

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NASEM study recommendations

- Recommendation 1: Shift the focus from pushing relief supplies to ensuring that regular supply chains are restored as rapidly as possible through strategic interventions.
- Recommendation 2. Build system-level understanding of supply chain dynamics as a foundation for effective decision support.
- Recommendation 3. Support mechanisms for coordination, information sharing, and preparedness among supply chain stakeholders.
- Recommendation 4: Develop and administer training on supply chain dynamics and best practices for private-public partnerships that enhance supply chain resilience.

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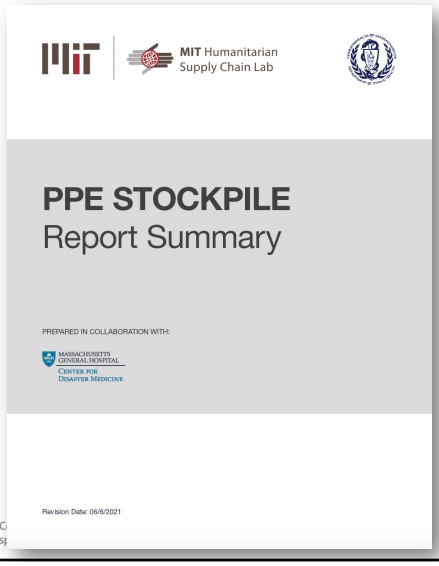
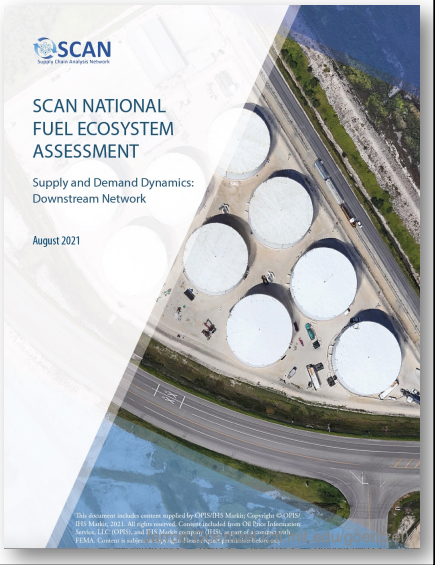
Source: National Academies of Sciences, Engineering, and Medicine (2020). *Strengthening Post-Hurricane Supply Chain Resilience: Observations from Hurricanes Harvey, Irma, and Maria*. Washington, DC: The National Academies Press.

Building system understanding from recent experiences

Demand and supply adaptation

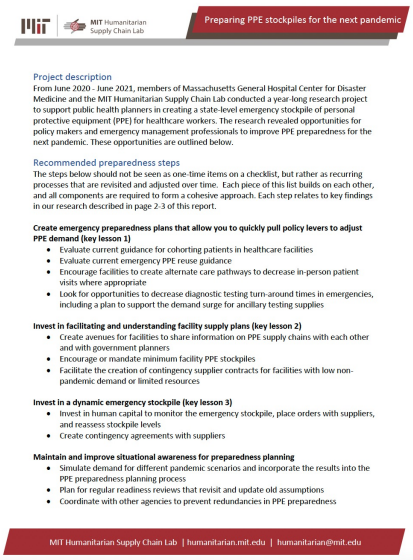


Distribution adaptation



Public summaries available

https://dspace.mit.edu/handle/1721.1/138837



MIT Humanitarian Supply Chain Lab

Preparing PPE stockpiles for the next pandemic

Project description

From June 2020 - June 2021, members of Massachusetts General Hospital Center for Disaster Medicine and the MIT Humanitarian Supply Chain Lab conducted a year-long research project to support public health planners in creating a state-level emergency stockpile of personal protective equipment (PPE) for healthcare workers. The research revealed opportunities for policy makers and emergency management professionals to improve PPE preparedness for the next pandemic. These opportunities are outlined below.

Recommended preparedness steps

The steps below should not be seen as one-time items on a checklist, but rather as recurring processes that are revisited and adjusted over time. Each piece of this list builds on each other, and all components are required to form a cohesive approach. Each step relates to key findings in our research described in page 2-3 of this report.

Create emergency preparedness plans that allow you to quickly pull policy levers to adjust PPE demand (key lesson 1)

- Evaluate current guidance for cohorting patients in healthcare facilities
- Evaluate current emergency PPE reuse guidance
- Encourage facilities to create alternate care pathways to decrease in-person patient visits where appropriate
- Look for opportunities to decrease diagnostic testing turn-around times in emergencies, including a plan to support the demand surge for ancillary testing supplies

Invest in facilitating and understanding facility supply plans (key lesson 2)

- Create avenues for facilities to share information on PPE supply chains with each other and with government planners
- Encourage or mandate minimum facility PPE stockpiles
- Facilitate the creation of contingency supplier contracts for facilities with low non-pandemic demand or limited resources

Invest in a dynamic emergency stockpile (key lesson 3)

- Invest in human capital to monitor the emergency stockpile, place orders with suppliers, and reassess stockpile levels
- Create contingency agreements with suppliers

Maintain and improve situational awareness for preparedness planning

- Simulate demand for different pandemic scenarios and incorporate the results into the PPE preparedness planning process
- Plan for regular readiness reviews that revisit and update old assumptions
- Coordinate with other agencies to prevent redundancies in PPE preparedness

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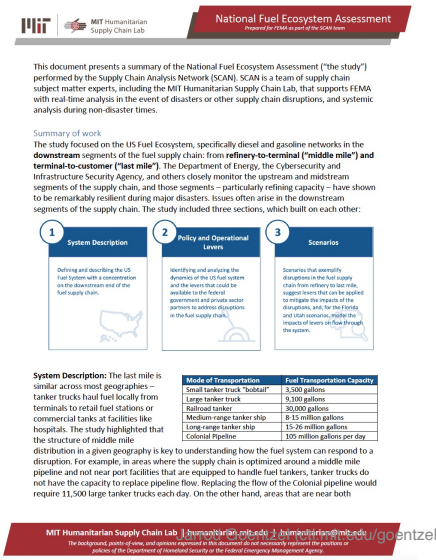
https://dspace.mit.edu/handle/1721.1/138838



MIT Humanitarian Supply Chain Lab

National Fuel Ecosystem Assessment

Prepared for FEMA as part of the SCAN team

This document presents a summary of the National Fuel Ecosystem Assessment ("the study") performed by the Supply Chain Analysis Network (SCAN). SCAN is a team of supply chain subject matter experts, including the MIT Humanitarian Supply Chain Lab, that supports FEMA with real-time analysis in the event of disasters or other supply chain disruptions, and systemic analysis during non-disaster times.

Summary of work

The study focused on the US Fuel Ecosystem, specifically diesel and gasoline networks in the **downstream** segments of the fuel supply chain: from **refinery-to-terminal ("middle mile") and terminal-to-customer ("last mile")**. The Department of Energy, the Cybersecurity and Infrastructure Security Agency, and others closely monitor the upstream and midstream segments of the supply chain, and those segments – particularly refining capacity – have shown to be remarkably resilient during major disasters. Issues often arise in the downstream segments of the supply chain. The study included three sections, which built on each other:

1 System Description

Defining and describing the US Fuel System with a concentration on the downstream end of the fuel supply chain.

2 Policy and Operational Levers

Identifying and analyzing the dynamics of the US fuel system and the levers that could be available to the federal government and private sector partners to address disruptions in the fuel supply chain.

3 Scenarios

Scenarios that exemplify disruptions in the fuel supply chain from refinery to last mile, suggest levers that can be applied to mitigate the impacts of the disruptions, and, for the Florida and Utah scenarios, model the impacts of levers on flow through the system.

System Description: The last mile is similar across most geographies – tanker trucks haul fuel locally from terminals to retail fuel stations or commercial tanks at facilities like hospitals. The study highlighted that the structure of middle mile distribution in a given geography is key to understanding how the fuel system can respond to a disruption. For example, in areas where the supply chain is optimized around a middle mile pipeline and not near port facilities that are equipped to handle fuel tankers, tanker trucks do not have the capacity to replace pipeline flow. Replacing the flow of the Colonial pipeline would require 11,500 large tanker trucks each day. On the other hand, areas that are near both

Mode of Transportation	Fuel Transportation Capacity
Small tanker truck "bobtail"	3,500 gallons
Large tanker truck	9,100 gallons
Railroad tanker	30,000 gallons
Medium-range tanker ship	8-15 million gallons
Long-range tanker ship	15-26 million gallons
Colonial Pipeline	105 million gallons per day

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The background, points-of-view, and opinions expressed in this document do not necessarily represent the positions or policies of the Department of Homeland Security or the Federal Emergency Management Agency.

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System understanding experience: Pandemic PPE

Supply and demand adaptation

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Jarrod Goentzel (ctl.mit.edu/goentzel)

Delivering Personal Protective Equipment to Liberian hospitals in 2014-2015

- Funded by the Paul G. Allen Family Foundation - #TackleEbola
- No financial interests/COI
- All photos with the verbal consent of individuals
- Credit goes to the team





Massachusetts Institute of Technology

Credit for several slides goes to Michelle Niescierenko

Jarrod Goentzel (ctl.mit.edu/goentzel)

PPE Specs

- Various products
- Various standards: US, European, International

Draft WHO list of Personal Protective Equipment for Infection and Prevention Control with Focus on Ebola - CLEANING, WASTE MANAGEMENT AND, SAFE AND DIGNIFIED BURIALS

Version 07 November 2014

Main reference

Personal protective equipment in the context of filovirus disease outbreak response rapid advice guideline: summary of the recommendations, WHO, October 2014	http://apps.who.int/iris/handle/10665/137429#sthash.B6DpJk7.dpuf
Personal protective equipment (PPE) in the context of filovirus disease outbreak response: Technical specifications for PPE equipment to be used by health workers providing clinical care for patients, WHO, October 2014	http://apps.who.int/iris/bitstream/10665/137411/1/WHO_EVD_Guidance_SpecPPE_14.1_eng.pdf?ua=1
Field situation: How to conduct safe and dignified burial of a patient who has died from suspected or confirmed Ebola virus disease, WHO, October 2014	http://apps.who.int/iris/bitstream/10665/137379/1/WHO_EVD_GUIDANCE_Burials_14.2_eng.pdf?ua=1
Interim Infection Prevention and Control Guidance for Care of Patients with Suspected or Confirmed Filovirus Haemorrhagic Fever in Health Care Settings, with Focus on Ebola, WHO, August 2014	http://www.who.int/csr/resources/publications/who-ipc-guidance-ebolafinal-20082014.pdf
Clinical management of patients with viral haemorrhagic fever: A pocket guide for the front-line health worker, WHO, March 2014	http://www.who.int/csr/resources/publications/clinical-management-patients/en/
Interagency Emergency Health Kit, WHO, 2011	http://www.who.int/medicines/publications/emergencyhealthkit2011/en/
WHO catalogue (WHO internal site)	http://intranet.who.int/tools/wcat/QuickSearch.aspx

*** Recommended
** Alternative
* Optional

Item	Generic item name	Generic item image		WHO Detailed description	Sizes	Certification or minimum testing (or equivalent)
Eyes protection (choose one of two)	Goggles		***	Good seal with the skin of the face, Flexible PVC frame to easily fit with all face contours without too much pressure, Enclose eyes and the surrounding areas, Accomodate wearers with prescription glasses, Clear plastic lens with fog and scratch resistant, Adjustable band to secure firmly so as not to become loose during clinical activity, Indirect venting to avoid fogging, May be re-usable (provided appropriate arrangements for decontamination are in place) or disposable.	One Size	• EU standard directive 86/686/EEC, EN 166/2002, • ANSI/ISEA Z87.1-2010, or equivalent
	OR					
	Face shield (full shield)		***	Made of clear plastic and provides good visibility to both the wearer and the patient, Adjustable band to attach firmly around the head and fit snuggly against the forehead, Fog resistant (preferable), Completely cover the sides and length of the face, May be re-usable (made of robust material which can be cleaned and disinfected) or disposable.	One Size	• EU standard directive 86/686/EEC, EN 166/2002, • ANSI/ISEA Z87.1-2010, or equivalent
Nose and mouth protection	Mask, medical/surgical, fluid resistant, structured design		***	High fluid resistance, Good breathability, Internal and external faces should be clearly identified, Structured design that does not collapse against the mouth (e.g. duckbill, cup-shape)	S, M, L	EN 14683 Type IIR performance ASTM F2100 level 2 or level 3 or equivalent; • Fluid resistance at minimum 120 mmHg pressure based on ASTM F1862-07, ISO 22609, or equivalent • Breathability: MIL-M-36945C, EN 14683 annex C, or equivalent • Filtration efficiency: ASTM F2101, EN14683 annex B, or equivalent
	OR					
	Respirator		*** (used for aerosols with full face shield)	Shape that will not collapse easily (e.g. duckbill, half-sphere), High filtration efficiency, Good breathability To be used only during procedures that generate aerosols of body fluids. Only to be used together with a full face shield.	range of sizes with fit test kit	NIOSH N95, EN149 FFP2, or equivalent: • Filtration efficiency: US 42 CFR Part 84 for N95, EN149 clause 7.9.2, or equivalent • Breathability: US 42 CFR Part 84 for N95, EN149 clause 7.16, or equivalent
	OR					
	Surgical N95 respirator		** (used for aerosols)	Fluid resistant, Shape that will not collapse easily (e.g. half-sphere), High filtration efficiency, Good breathability To be used only during procedures that generate aerosols of body fluids.	range of sizes with fit test kit	"Surgical N95 respirator" cleared by the US FDA, or equivalent • Fluid resistant surgical N95 respirator with minimum 80 mm Hg pressure based on ASTM F1862, ISO 22609 , or equivalent
	Alcohol-based hand rub		***	Preferably made locally (refer to main reference), Fulfils recognized standards for microbiological efficacy (ASTM or EN standards), contains 60-85% 'alcohol' depending on ingredients (ethanol or isopropanol), can be liquid, gel or foam (and HCW tolerability & acceptability has already been tested), can be in 100ml (personal) bottles (should be able to be opened with one hand, e.g. flip top bottle), 500ml bottles (preferably with wall/bed/trolley mounted bracket) or 1lt bottles	100 mL 500 mL 1 L	• ASTM E2315 • ASTM E2755 - 10 or equivalent

Massachusetts Institute of Technology

Manufacturer Specs

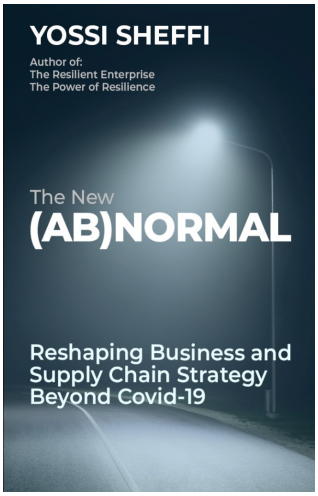
Fig 1. Standard Médecins Sans Frontière ensemble. Adapted from: http://www.bbc.com/news/health-29518703.

Source: Garibaldi, B., et. al. (2018) "A novel personal protective equipment coverall was rated higher than standard Ebola virus personal protective equipment in terms of comfort, mobility and perception of safety when tested by health care workers in Liberia and in a United States biocontainment unit," *American Journal of Infection Control*, (in press) DOI 10.1016/j.ajic.2018.08.014

Massachusetts Institute of Technology

Adapting manufacturing capacity during Covid-19

mask makers ramped up production—China alone increased its total production tenfold to 40 billion per year.[31] One of the many companies using its assets to make masks was Boston-based athletic apparel company New Balance (*see* Chapter 25). At Walmart, CEO Doug McMillon said, "We've also asked some of our apparel suppliers to convert production to PPE for healthcare workers."[32] Many other retailers and manufacturers—including Eddie Bauer, Hanesbrands, Gap, Ralph Lauren, Canada Goose, L.L. Bean, and others—started making and distributing protective masks and gowns.



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Jarrod Goentzel (ctl.mit.edu/goentzel)

Adding manufacturing capacity during Covid-19

- It is hard to know precisely how many companies were born during the pandemic; 36 of them are members of the American Mask Manufacturer's Association
- As soon as the waves crested, and Chinese companies, determined to regain their market share, began exporting masks below cost, the customers disappeared
- The federal government spent $682 billion buying goods and services from contractors in 2020…but it's only about 3 percent of America's $21.5 trillion economy.

Source: https://www.nytimes.com/2022/03/05/business/dealbook/american-mask-makers.html

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Why American Mask Makers Are Going Out of Business

Efforts to make the supply chain more resilient after pandemic shortages are no match for low-price foreign products, the companies say.

Luis Arguello Jr., vice president of DemeTech, a medical supply manufacturer, in 2021. DemeTech has laid off virtually all the employees it hired during the pandemic to make masks, and it has shut most of its mask manufacturing center. Scott McIntyre for The New York Times

By Joe Nocera

Published March 5, 2022 Updated March 7, 2022

PPE adaptation related to Covid-19

- Production capacity
  - Adapting to tap adjacent production capacity is essential to meet exponential growth in demand, e.g. PPE during a pandemic
  - Nearsourcing initiatives may not be sustainable
- Inventory buffer
  - Just in time: hospitals rely on daily restocking from their medical distributor
  - Just in case: hospital stockpiles emerged during the pandemic, but may not be sustainable
  - JIT is only one part of TPS; some hospitals establishing direct relationships with producers
  - State strategic stockpiling initiatives emerged to supplement national stockpiles
- Demand management
  - Crisis Standards of Care were applied during Covid-19

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Jarrod Goentzel (ctl.mit.edu/goentzel)

Motivation

ASPR Office of the Assistant Secretary for Preparedness & Response

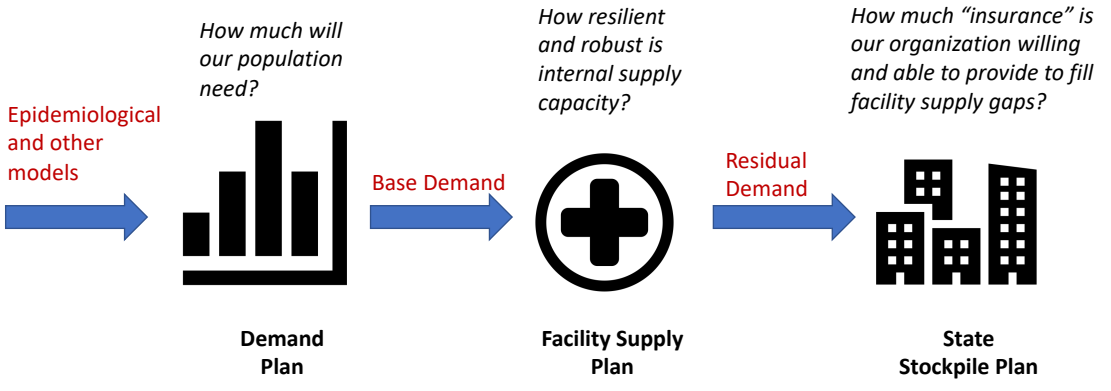
- From July 2020 – July 2021 our team conducted research funded by the Assistant Secretary for Preparedness & Response (ASPR) determining the appropriate PPE stockpile for a state level public health agency.

- Over the course of this research, we conducted:
  - 30 subject matter expert interviews
  - Analyzed a survey with numerous responses
  - 14 meetings with state representatives

MASSACHUSETTS GENERAL HOSPITAL CENTER FOR DISASTER MEDICINE

MIT Humanitarian Supply Chain Lab

Preparedness plan framework



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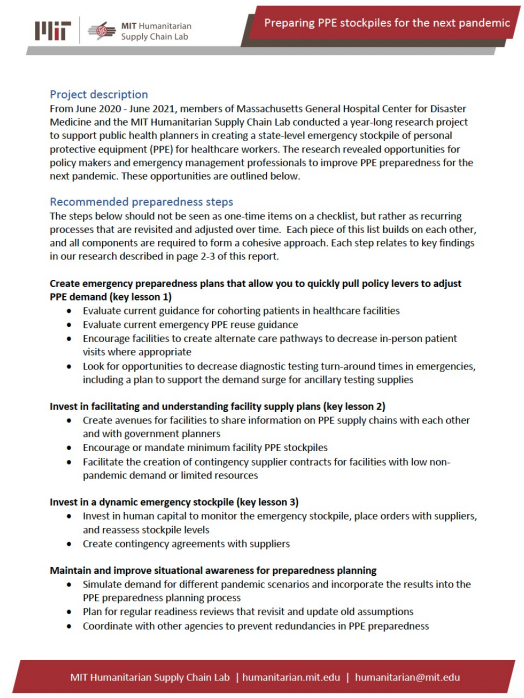
Summary available

https://dspace.mit.edu/handle/1721.1/138837



MIT Humanitarian Supply Chain Lab

Preparing PPE stockpiles for the next pandemic

Project description

From June 2020 - June 2021, members of Massachusetts General Hospital Center for Disaster Medicine and the MIT Humanitarian Supply Chain Lab conducted a year-long research project to support public health planners in creating a state-level emergency stockpile of personal protective equipment (PPE) for healthcare workers. The research revealed opportunities for policy makers and emergency management professionals to improve PPE preparedness for the next pandemic. These opportunities are outlined below.

Recommended preparedness steps

The steps below should not be seen as one-time items on a checklist, but rather as recurring processes that are revisited and adjusted over time. Each piece of this list builds on each other, and all components are required to form a cohesive approach. Each step relates to key findings in our research described in page 2-3 of this report.

Create emergency preparedness plans that allow you to quickly pull policy levers to adjust PPE demand (key lesson 1)

- Evaluate current guidance for cohorting patients in healthcare facilities
- Evaluate current emergency PPE reuse guidance
- Encourage facilities to create alternate care pathways to decrease in-person patient visits where appropriate
- Look for opportunities to decrease diagnostic testing turn-around times in emergencies, including a plan to support the demand surge for ancillary testing supplies

Invest in facilitating and understanding facility supply plans (key lesson 2)

- Create avenues for facilities to share information on PPE supply chains with each other and with government planners
- Encourage or mandate minimum facility PPE stockpiles
- Facilitate the creation of contingency supplier contracts for facilities with low non-pandemic demand or limited resources

Invest in a dynamic emergency stockpile (key lesson 3)

- Invest in human capital to monitor the emergency stockpile, place orders with suppliers, and reassess stockpile levels
- Create contingency agreements with suppliers

Maintain and improve situational awareness for preparedness planning

- Simulate demand for different pandemic scenarios and incorporate the results into the PPE preparedness planning process
- Plan for regular readiness reviews that revisit and update old assumptions
- Coordinate with other agencies to prevent redundancies in PPE preparedness

MIT Humanitarian Supply Chain Lab | humanitarian.mit.edu | humanitarian@mit.edu

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System understanding experience: Colonial Pipeline Cyberattack

Distribution adaptation

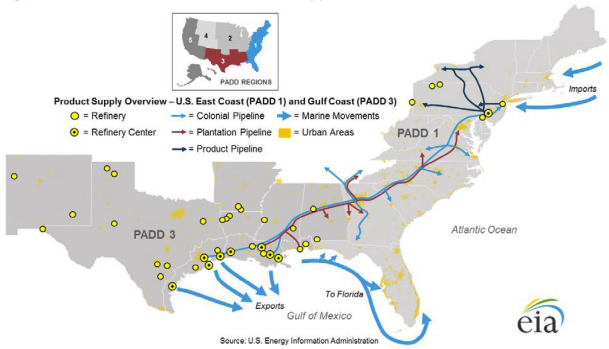
MIT Center for Transportation & Logistics

Jarrod Goentzel (ctl.mit.edu/goentzel)

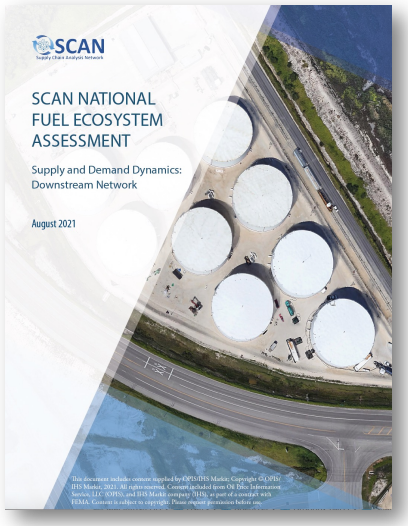
National fuel assessment for FEMA

Motivation: May 2021 ransomware cyber attack on the Colonial Pipeline

Figure 6. East Coast and Gulf Coast refineries and key product flows



Source: U.S. Department of Energy, Energy Information Administration, Independent Statistics & Analysis. (2016 February). *East Coast and Gulf Coast Transportation Fuels Markets*. Retrieved from https://www.eia.gov/analysis/transportationfuels/padd1n3/pdf/transportation_fuels_padd1n3.pdf



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Profiled 43 public and private sector levers to increase fuel flow

Supply chain segment	*Subclassifications of levers*	
Supply	Domestic stocks	Public
		Private
	International stocks	
	Priority procurement	Priority ratings
		Emergency contracts
	Production surge	
Demand	Demand restraint	Long term
		Short term
	Fuel switching	Long term
		Short term
Distribution	Middle mile	Increase flow
		Increase capacity
	Last mile	Increase flow
		Increase capacity

43 levers identified

Data were gathered on each lever across several attributes including:

- *Background*
- *Historic use*
- ***Impact***
- *Limitations*
- ***Type - operational or enabling***

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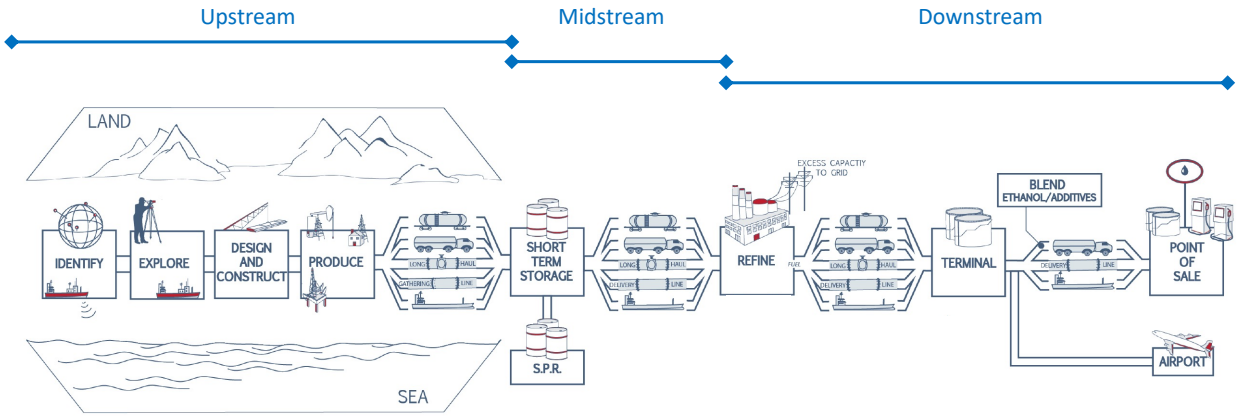
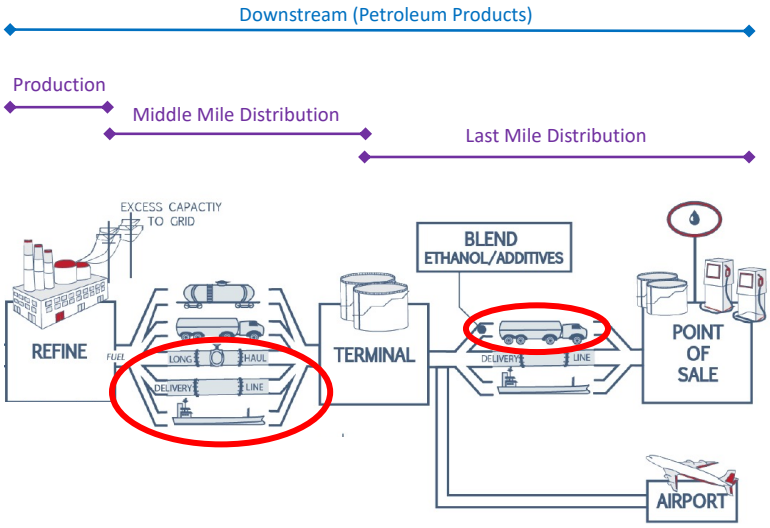
Segments of the fuel supply chain



Graphic attributed to the American Petroleum Institute (API)

Subsystems in the downstream segment



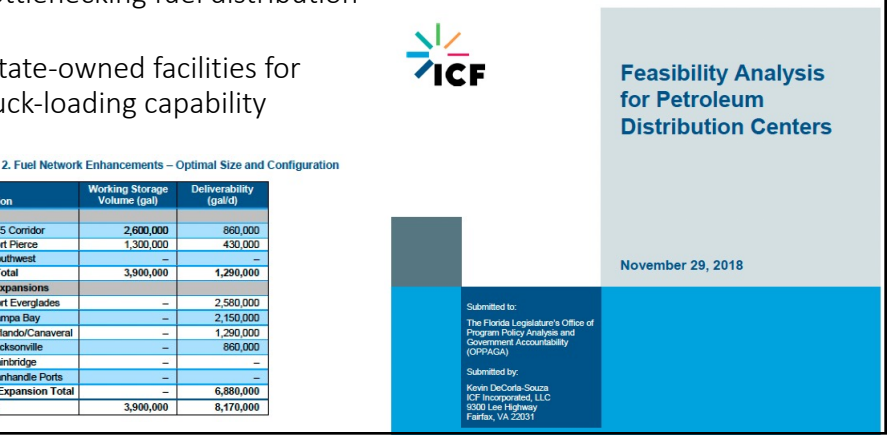
Graphic attributed to the American Petroleum Institute (API)

Government analysis following Hurricane Irma focused on building capacity

- Evaluated a two-pronged strategy aimed at enhancing the state's gasoline deliverability
  - Rack Expansions – debottlenecking fuel distribution at existing terminals
  - Establish PDCs – build state-owned facilities for gasoline storage and truck-loading capability

Exhibit 2. Fuel Network Enhancements – Optimal Size and Configuration

Location	Working Storage Volume (gal)	Deliverability (gal/d)
PDCs		
A) I-75 Corridor	2,600,000	860,000
B) Fort Pierce	1,300,000	430,000
C) Southwest	–	–
PDC Total	3,900,000	1,290,000
Rack Expansions		
D) Port Everglades	–	2,580,000
E) Tampa Bay	–	2,150,000
F) Orlando/Canaveral	–	1,290,000
G) Jacksonville	–	860,000
H) Bainbridge	–	–
I) Panhandle Ports	–	–
Rack Expansion Total	–	6,880,000
Total	3,900,000	8,170,000



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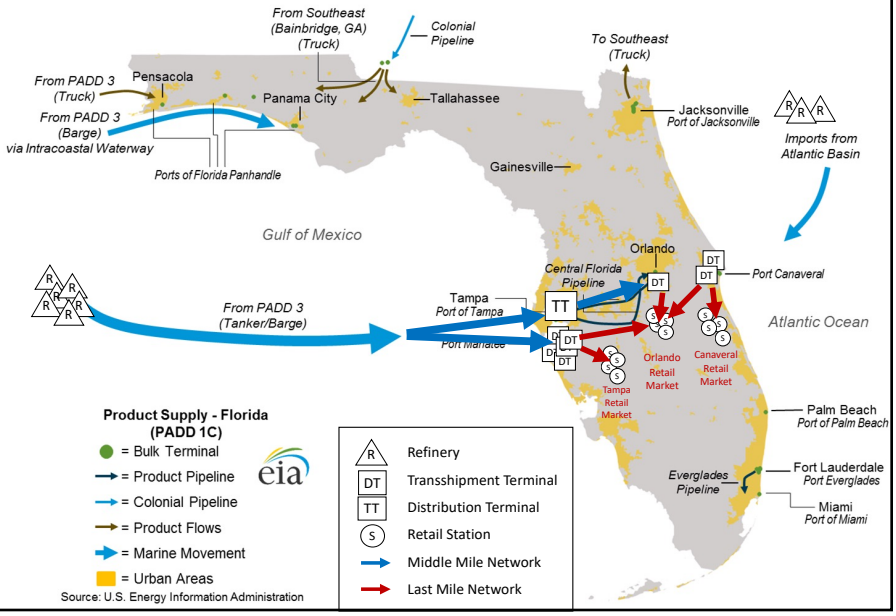
Analyzing distribution processes and stocks



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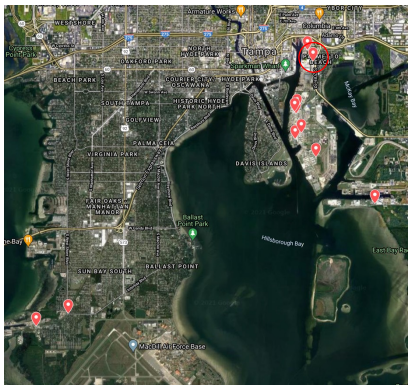
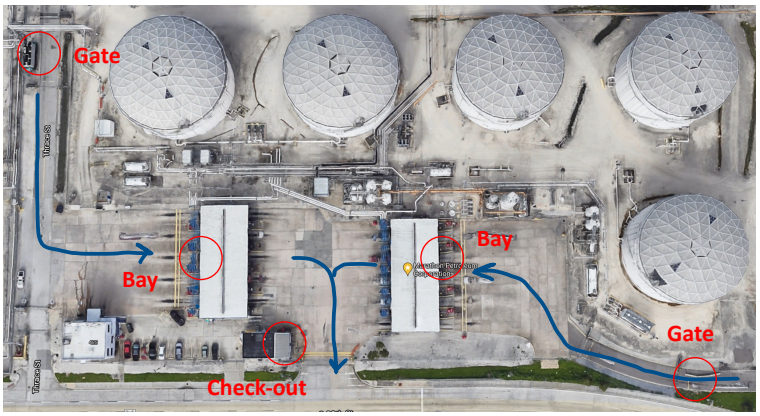
Analyzing distribution processes and stocks

Terminal Grouping



Terminal



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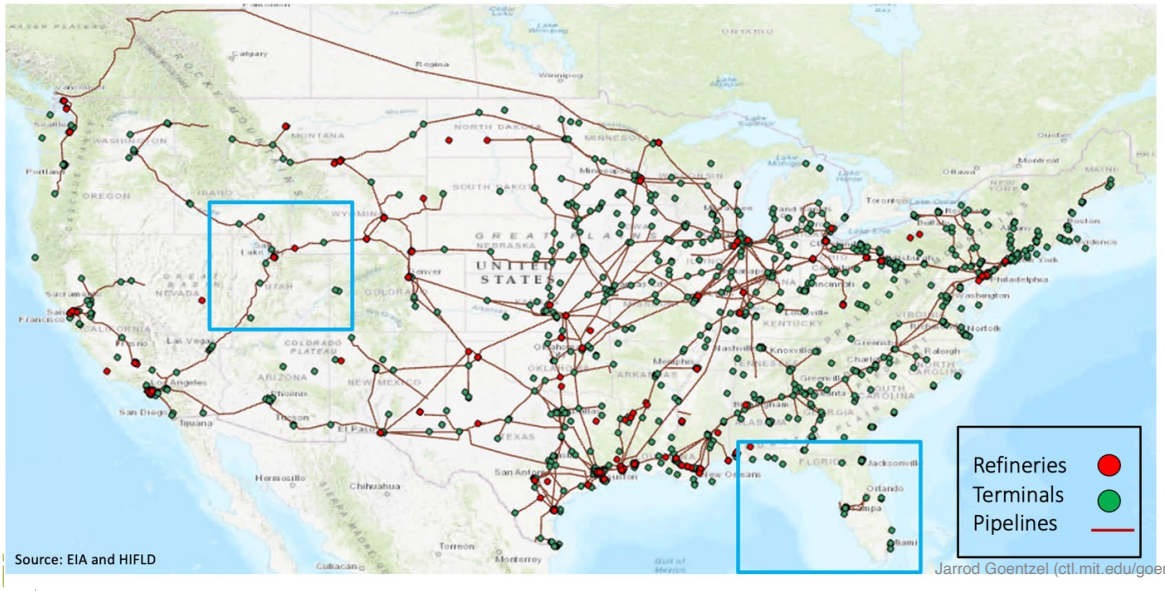
Highlighting two of the case studies



Source: EIA and HIFLD

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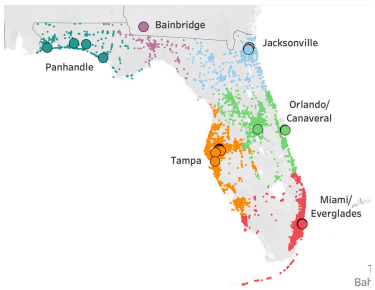
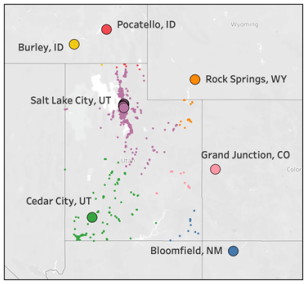
Last mile surge capacity for terminals with stock





Lever Status					Simulation Results - Surge Capacity			
Gate Rate	Bay Rate	Speed	Fleet Size	Hours of Service	FL Nominal	FL No Tampa	UT Nominal	UT No SLC
Normal	Normal	Normal	Normal	Normal	136%	97%	179%	27%
Normal	Normal	Normal	Normal	High	186%	132%	247%	39%
High	High	High	High	High	247%	177%	284%	50%

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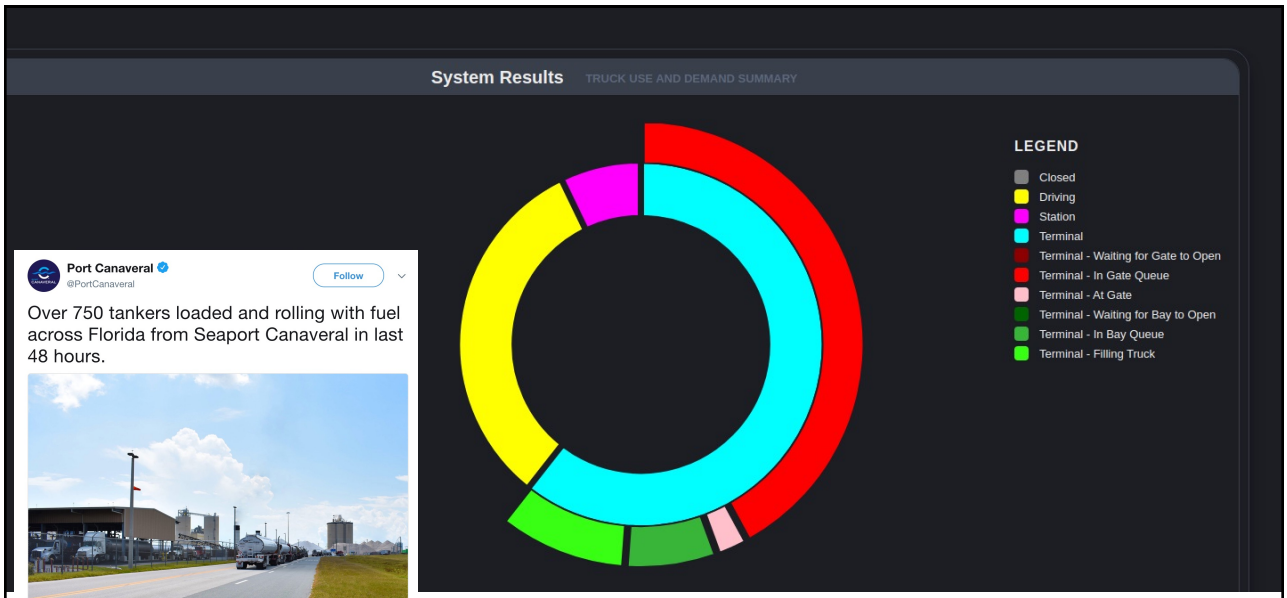

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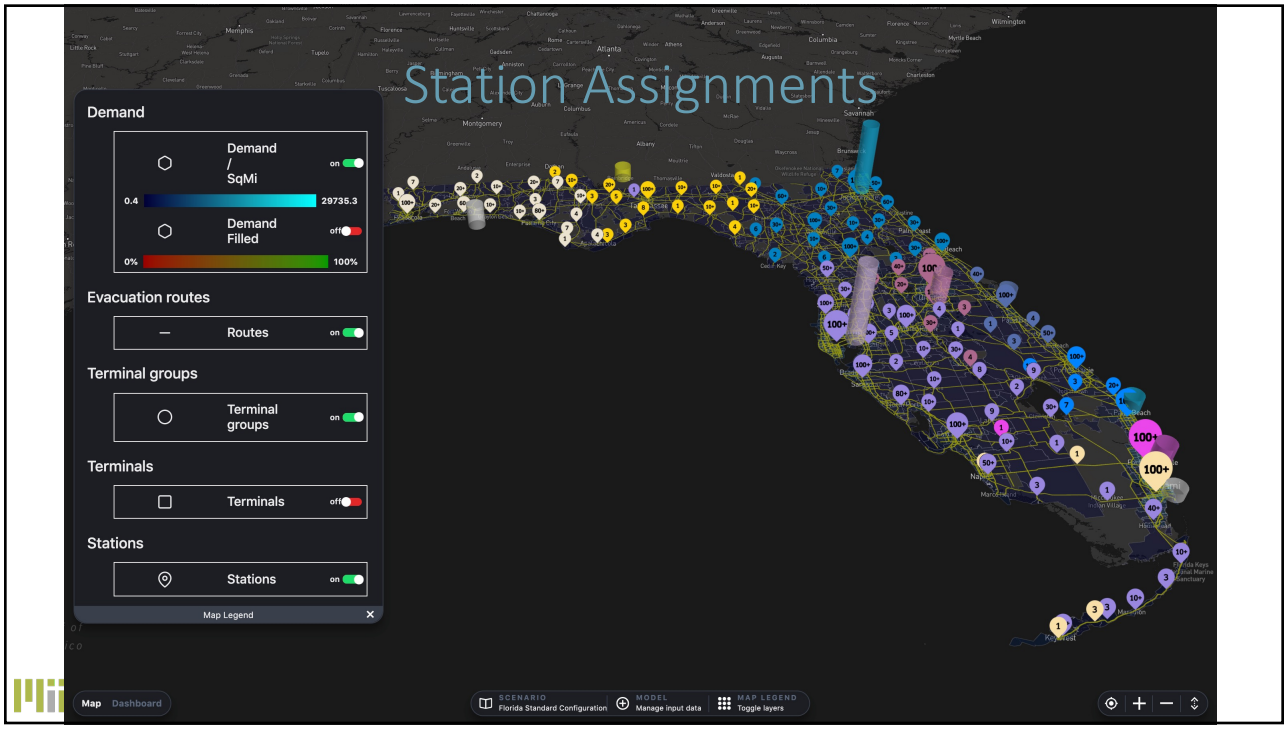
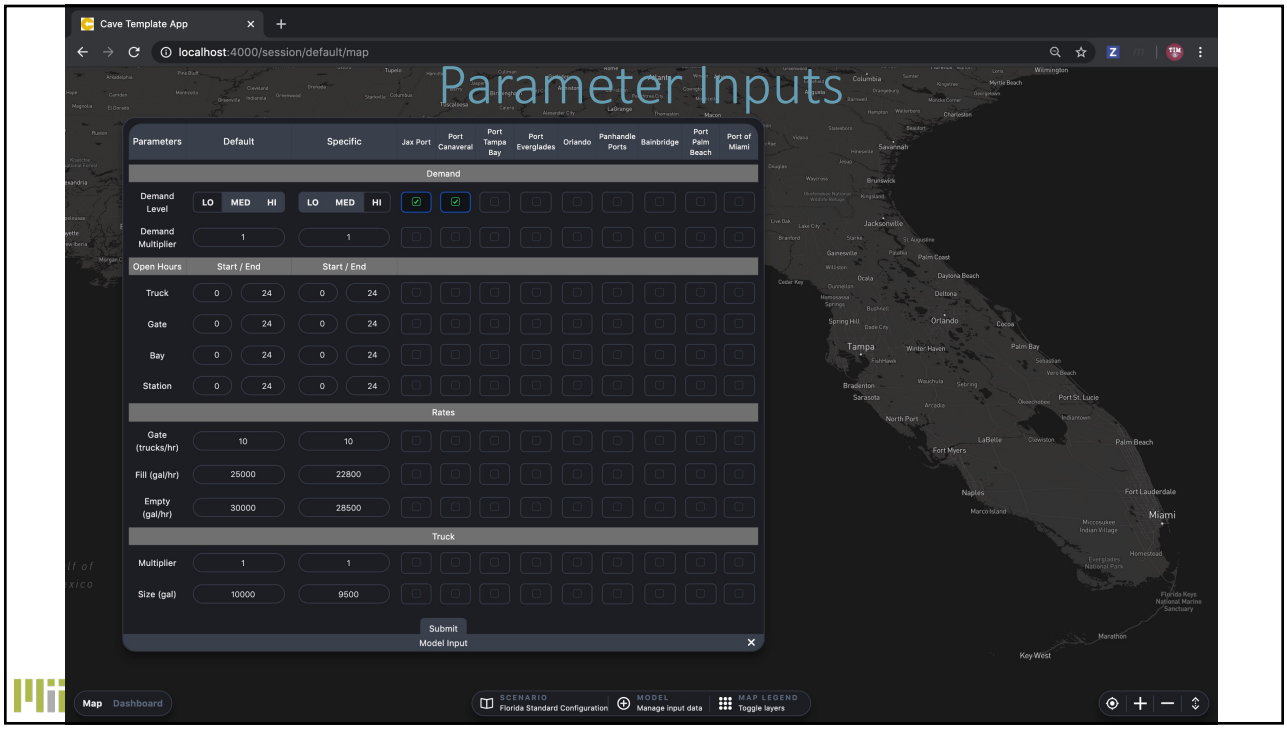
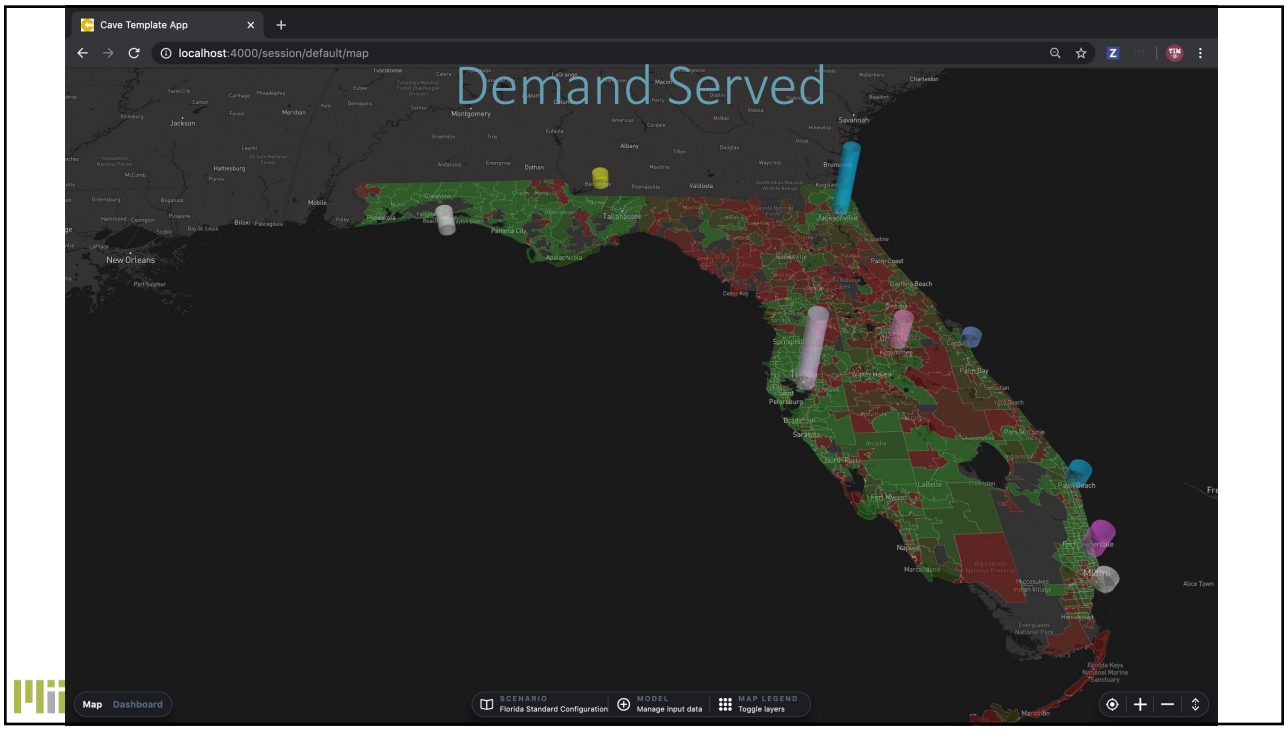
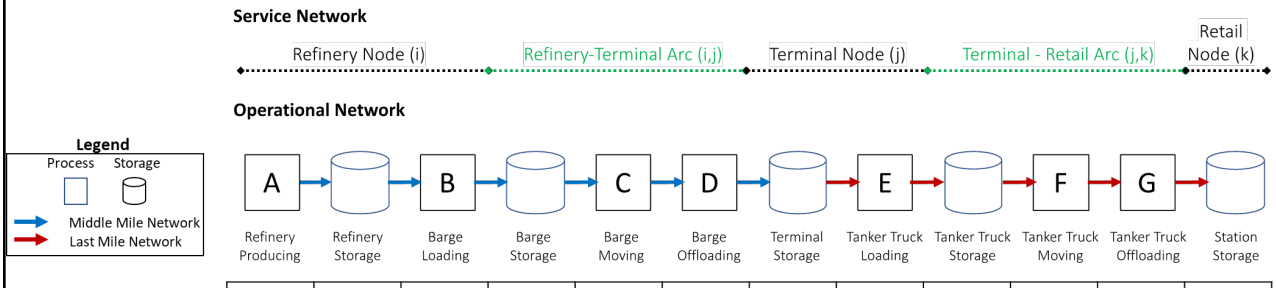
Dashboard
Demand per Area
Demand Filled
System Results
Demand
Truck Use
Dashboard


Station Assignments
Demand
Demand / SqMi
Demand Filled
Evacuation routes
Routes
Terminal groups
Terminal groups
Terminals
Terminals
Stations
Stations
Map Legend
Map
Dashboard
SCENARIO
Florida Standard Configuration
MODEL
Manage input data
MAP LEGEND
Toggle layers


Parameter Inputs
Cave Template App
localhost:4000/session/default/map
Parameters
Default
Specific
Jax Port
Port Canaveral
Port Tampa Bay
Port Everglades
Orlando
Panhandle Ports
Bainbridge
Port Palm Beach
Port of Miami
Demand
Demand Level
LO MED HI
Demand Multiplier
Open Hours
Start / End
Truck
Gate
Bay
Station
Rates
Gate (trucks/hr)
Fill (gal/hr)
Empty (gal/hr)
Truck
Multiplier
Size (gal)
Submit
Model Input
Map
Dashboard
SCENARIO
Florida Standard Configuration
MODEL
Manage input data
MAP LEGEND
Toggle layers


Demand Served
Cave Template App
localhost:4000/session/default/map
Map
Dashboard
SCENARIO
Florida Standard Configuration
MODEL
Manage input data
MAP LEGEND
Toggle layers

Generalized framework to analyze fuel distribution



Flow	r_A		r_B		r_C	r_D		r_E		r_F	r_G	
Stock		s_i		$s_{i,j}$			s_j		$s_{j,k}$			s_k
Cycle Time	t_A		t_B		t_C	t_D		t_E		t_F	t_G	
Capacity	R_A	S_i	R_B	$S_{i,j}$	R_C	R_D	S_j	R_E	$S_{j,k}$	R_F	R_G	S_k
Utilization	u_A	u_i	u_B	$u_{i,j}$	u_C	u_D	u_j	u_E	$u_{j,k}$	u_F	u_G	u_k

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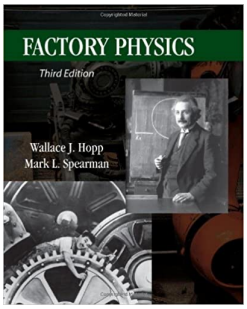
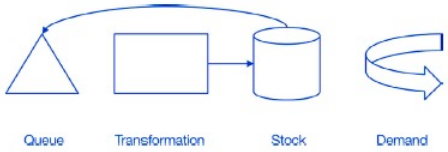
Factory Physics to Operations Science

- Mainstream texts on production and operations management have emphasized axiomatic models and general analysis techniques.
- Most empirical papers analyze specific problems rather than seek out universal behaviors of operations systems.
- We need a framework as the foundation for a true descriptive science.



Spearman and Hopp: *The Case for a Unified Science of Operations*
nt 30(3), pp. 802–814, © 2020 Production and Operations Management Society

Figure 4 Primitive Element of an Operation [Color figure can be viewed at wileyonlinelibrary.com]



Spearman, M. L., & Hopp, W. J. (2021). The case for a unified science of operations. *Production and Operations Management*, *30*(3), 802-814.

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System adaptation

Cooperative monitoring and problem solving

Persistent disruption and resilience

- Supply chain disruption has persisted
- Increased focus on supply chain resilience
  - Actors traditionally take a "hold your breath" approach to disruption / acute disequilibrium
  - Potential for chronic disequilibrium as social (labor), environmental (extreme weather, regulation), and political (trade regulation, conflict) stresses increase
- Complement supply chain optimization with system adaptation
  - Deep study of the complex adaptive systems that comprise global supply chains
  - Process to identify weak signals and rapidly validate emerging issues
  - Evidence to pre-stage effective interventions (policy, capacity, management, etc.)

NASEM study recommendations

- Recommendation 1: Shift the focus from pushing relief supplies to ensuring that regular supply chains are restored as rapidly as possible through strategic interventions.
- Recommendation 2. Build system-level understanding of supply chain dynamics as a foundation for effective decision support.
- Recommendation 3. Support mechanisms for coordination, information sharing, and preparedness among supply chain stakeholders.
- Recommendation 4: Develop and administer training on supply chain dynamics and best practices for private-public partnerships that enhance supply chain resilience.

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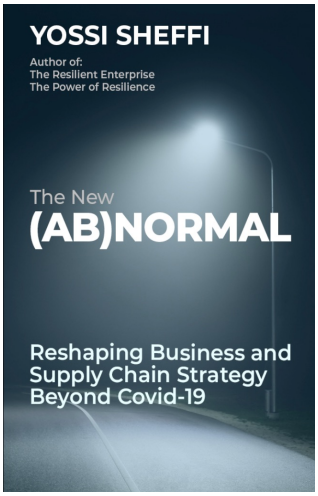
Source: National Academies of Sciences, Engineering, and Medicine (2020). *Strengthening Post-Hurricane Supply Chain Resilience: Observations from Hurricanes Harvey, Irma, and Maria*. Washington, DC: The National Academies Press.

Increased supply chain monitoring during Covid-19

Companies monitor the health of their suppliers via special services (such as Dun & Bradstreet for public companies), banking relationships, news media, social media, and information collected by local tiger teams. They watch for layoffs, scandals, morale problems, turmoil in upper management, and financial troubles. Even something as simple as a dirty or messy factory can signal a potential problem. In many cases, suppliers' operational hiccups (e.g., product defects, late deliveries, incomplete orders) signify that management is preoccupied by issues other than customer service. During the pandemic, supplier monitoring included assessment of the infection risks associated with a supplier's HR practices that might force a facility shutdown, as happened in a number of meatpacking plants in the US, Germany, and elsewhere.[18]



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Cooperative monitoring during crisis


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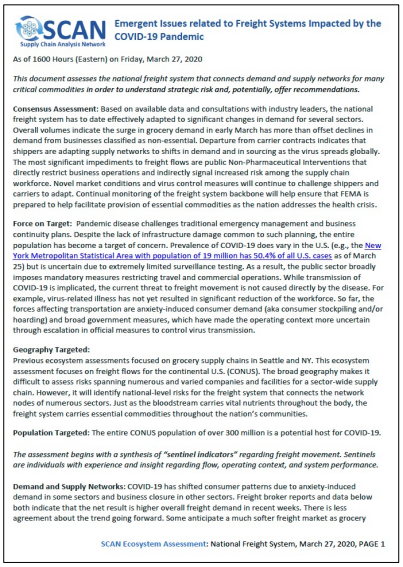
Near real-time, peer-reviewed hypothesis verification informs FEMA on Covid-19 supply chain risks

The MIT Humanitarian Supply Chain Lab implements a rapid assessment process to inform policy.

Arthur Grau | Center for Transportation and Logistics
June 18, 2020

PRESS INQUIRIES


SCAN Supply Chain Analysis Network

Emergent Issues related to Freight Systems Impacted by the COVID-19 Pandemic

As of 1600 Hours (Eastern) on Friday, March 27, 2020

This document assesses the national freight system that connects demand and supply networks for many critical commodities in order to understand strategic risk and, potentially, offer recommendations.

Consensus Assessment: Based on available data and consultations with industry leaders, the national freight system has to date effectively adapted to significant changes in demand for several sectors. Overall volumes indicate the surge in grocery demand in early March has more than offset declines in demand from businesses classified as non-essential. Departure from carrier contracts indicates that shippers are adapting supply networks to shifts in demand and in sourcing as the virus spreads globally. The most significant impediments to freight flows are public Non-Pharmaceutical Interventions that directly restrict business operations and indirectly signal increased risk among the supply chain workforce. Novel market conditions and virus control measures will continue to challenge shippers and carriers to adapt. Continual monitoring of the freight system backbone will help ensure that FEMA is prepared to help facilitate provision of essential commodities as the nation addresses the health crisis.

Force on Target: Pandemic disease challenges traditional emergency management and business continuity plans. Despite the lack of infrastructure damage common to such planning, the entire population has become a target of concern. Prevalence of COVID-19 does vary in the U.S. (e.g., the New York Metropolitan Statistical Area with population of 19 million has 50.4% of all U.S. cases as of March 25) but is uncertain due to extremely limited surveillance testing. As a result, the public sector broadly imposes mandatory measures restricting travel and commercial operations. While transmission of COVID-19 is implicated, the current threat to freight movement is not caused directly by the disease. For example, virus-related illness has not yet resulted in significant reduction of the workforce. So far, the forces affecting transportation are anxiety-induced consumer demand (aka consumer stockpiling and/or hoarding) and broad government measures, which have made the operating context more uncertain through escalation in official measures to control virus transmission.

Geography Targeted:
Previous ecosystem assessments focused on grocery supply chains in Seattle and NY. This ecosystem assessment focuses on freight flows for the continental U.S. (CONUS). The broad geography makes it difficult to assess risks spanning numerous and varied companies and facilities for a sector-wide supply chain. However, it will identify national-level risks for the freight system that connects the network nodes of numerous sectors. Just as the bloodstream carries vital nutrients throughout the body, the freight system carries essential commodities throughout the nation's communities.

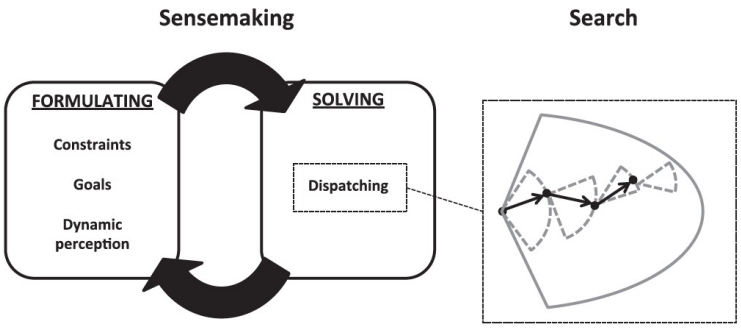
Population Targeted: The entire CONUS population of over 300 million is a potential host for COVID-19.

The assessment begins with a synthesis of "sentinel indicators" regarding freight movement. Sentinels are individuals with experience and insight regarding flow, operating context, and system performance.

Demand and Supply Networks: COVID-19 has shifted consumer patterns due to anxiety-induced demand in some sectors and business closure in other sectors. Freight broker reports and data below both indicate that the net result is higher overall freight demand in recent weeks. There is less agreement about the trend going forward. Some anticipate a much softer freight market as grocery

SCAN Ecosystem Assessment: National Freight System, March 27, 2020, PAGE 1

Cooperative problem solving during crisis (actually pre-crisis training)



Gralla, E., Goentzel, J. and Fine, C. "Problem formulation and solution mechanisms: a behavioral study of humanitarian transportation planning." *Production and Operations Management*, Volume 25, Issue 1, pages 22–35, January 2016.

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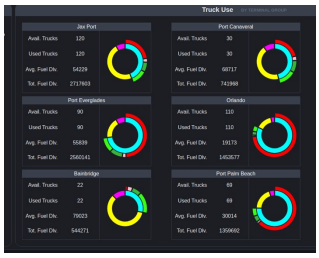
Jarrod Goentzel (ctl.mit.edu/goentzel)

Cooperative problem solving pre-crisis

- Solving challenging problems supports training and preparedness
- Forming supply chain relationships is essential for dynamic adaptation



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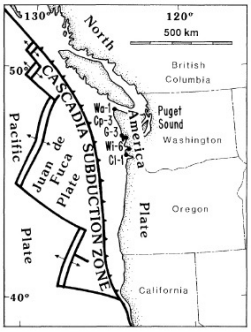
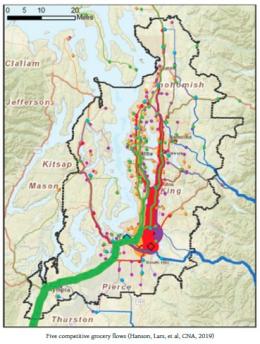
There are plenty of challenging problems out there

- Cascadia Subduction Zone
- Geologic history indicates high probability of a great earthquake (magnitude about 8 or 9) in the Pacific Northwest.
- Grocery distribution centers accounting for roughly 80% of household food consumption are likely to suffer considerable damage
  - 4 of 5 DCs serving metropolitan Seattle
  - 3 of 5 DCs serving metropolitan Portland
- National Level Exercise in June 2022





Five competitive grocery flows (Hanson, Lars, et al, CNA, 2019)

Source: https://supplychainresilience.org/he-looks-at-the-earth/

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Ukraine crisis

Ukraine Emergency

Situation Report #1

As of 01 March 2022

LOGISTICS CLUSTER

Gaps & Bottlenecks

- Partners are encouraged to reach out and share resources (*e.g.* storage space, transport solutions). The Logistics Cluster is developing mechanisms to eliminate duplication of service delivery to address gaps and to increase the effectiveness of humanitarian response by building partnerships.
- Transport main challenges currently include:
  - Most Polish transporters are not willing to cross the border into Ukraine due to growing insecurity and inadequate insurance coverage.
  - Ukrainian transporters are unable to get into Poland due to conflict-related restrictions limiting their outwards movements.
- Krakow and Rzeszow airports authorities have been reached out by WFP aviation as a significant amount of cargo is expected to arrive in-country in the coming days. Rzeszow airport's storage area may quickly be congested.
  - The possibility to transport cargo from Rzeszow to Lviv using railway is currently considered. The relevant authorities have been contacted and the feasibility is under evaluation. The main challenge is the availability of staff on Ukrainian side.
  - Ukrainian airspace remains closed to passenger and cargo flights.
  - Sea access is currently not practicable.
  - For more information, interested partners can refer to the Concept of Operations.

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Ukraine crisis

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Questions

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