Supply Chain Adaptation to Persistent Disruption

MIT Manufacturing Conference
March 16, 2022

Jarrod Goentzel

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.

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 vigorous 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

GUIDANCE ON THE ESSENTIAL CRITICAL INFRASTRUCTURE WORKFORCE

Original release date: March 15, 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. This document is intended to support pandemic risk assessment.

CISA issued the guidance originally on March 15 and has continued to update it based on feedback from the Critical Infrastructure community. The most recent update on April 17, 2020, clarifies the designation of a small number of essential workers and updates the list.

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

Taxonomy Topics: Infrastructure Security

Attachment
- Version 3.0 - CISA's Guidance on Essential Critical Infrastructure Workers (765.40 KB)
- Ver 3.0 - Guía sobre la Fuerza de Trabajo Esencial de Infraestructura Crítica (697.66 KB)
- Ver 3.0 - Études directrices sur les travailleurs essentiels des infrastructures critiques (670.51 KB)
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 15, 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

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
(424) 639-3236

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 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 York area.
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.
- 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.

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)
What happened in March 2020?

What happened in April 2020?
What happened next?
Persistent disruption

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


Persistent demand pressure

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

Shaded areas indicate U.S. recessions. Source: U.S. Bureau of Economic Analysis

fred.stlouisfed.org
Persistent demand pressure

- 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
Increased focus on supply chain resilience

Google Trends

“supply chain”

“resilience”
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
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.

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”

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.


Building system understanding from recent experiences
Public summaries available

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

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

System understanding experience:

Pandemic PPE

Supply and demand adaptation
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

PPE Specs

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

Adapting manufacturing capacity during Covid-19

mask makers ramped up production—China alone increased its total production tenfold to 40 billion per year. 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.” 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.
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/2022/03/06/business/dealbook/american-mask-makers.html

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.

Jarrod Goentzel (ctl.mit.edu/goentzel)

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
Motivation

• 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

Preparedness plan framework

Epidemiological and other models

How much will our population need?

Demand Plan

Base Demand

How resilient and robust is internal supply capacity?

Facility Supply Plan

Residual Demand

How much “insurance” is our organization willing and able to provide to fill facility supply gaps?

State Stockpile Plan
Summary available
https://dspace.mit.edu/handle/1721.1/138837

System understanding experience:
Colonial Pipeline Cyberattack
Distribution adaptation
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


Profiled 43 public and private sector levers to increase fuel flow

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

43 levers identified

Data were gathered on each lever across several attributes including:
- Background
- Historic use
- Impact
- Limitations
- Type - operational or enabling
Segments of the fuel supply chain

- **Upstream**
- **Midstream**
- **Downstream**

Subsystems in the downstream segment

- **Production**
- **Middle Mile Distribution**
- **Last Mile Distribution**

Graphic attributed to the American Petroleum Institute (API)

Over 750 tankers loaded and rolling with fuel across Florida from Seaport Canaveral in last 48 hours.

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

<table>
<thead>
<tr>
<th>Location</th>
<th>Working Storage (Tanker/Truck)</th>
<th>Deliverability (Tanker)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDCs</td>
<td>3,400,000</td>
<td>600,000</td>
</tr>
<tr>
<td>Florida</td>
<td>1,500,000</td>
<td>430,000</td>
</tr>
<tr>
<td>Southeast</td>
<td>2,000,000</td>
<td>1,200,000</td>
</tr>
<tr>
<td>PDC Total</td>
<td>6,900,000</td>
<td>2,230,000</td>
</tr>
<tr>
<td>Rack Expansions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>2,100,000</td>
<td></td>
</tr>
<tr>
<td>GA</td>
<td>2,100,000</td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>Orlando/University</td>
<td>2,100,000</td>
</tr>
<tr>
<td>FL</td>
<td>Jacksonville</td>
<td>2,100,000</td>
</tr>
<tr>
<td>FL</td>
<td>Panama Bay</td>
<td>600,000</td>
</tr>
<tr>
<td>FL</td>
<td>Petroleum Port</td>
<td>600,000</td>
</tr>
<tr>
<td>Rack Expansion Total</td>
<td>6,400,000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5,500,000</td>
<td>8,130,000</td>
</tr>
</tbody>
</table>

### Analyzing distribution processes and stocks

- Refinery
- Transshipment Terminal
- Distribution Terminal
- Retail Station
- Middle Mile Network
- Last Mile Network
Analyzing distribution processes and stocks

Terminal Grouping

Terminal

Highlighting two of the case studies

Source: EIA and HIFLD
Last mile surge capacity for terminals with stock

<table>
<thead>
<tr>
<th>Lever Status</th>
<th>Simulation Results - Surge Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FL Nominal</td>
</tr>
<tr>
<td>Normal Normal Normal Normal Normal</td>
<td>136%</td>
</tr>
<tr>
<td>Normal Normal Normal Normal High</td>
<td>186%</td>
</tr>
<tr>
<td>High High High High High</td>
<td>247%</td>
</tr>
</tbody>
</table>

Over 750 tankers loaded and rolling with fuel across Florida from Seaport Canaveral in last 48 hours.
Dashboard

Station Assignments
### Parameter Inputs

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default</th>
<th>Specific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Label</td>
<td>LD</td>
<td>NE</td>
</tr>
<tr>
<td>Demand</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Truck</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Code</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Key</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Knob</td>
<td>0</td>
<td>24</td>
</tr>
</tbody>
</table>

### Demand-Served

<table>
<thead>
<tr>
<th>Resource</th>
<th>Default</th>
<th>Specific</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bin</td>
<td>5000</td>
<td>1000</td>
</tr>
</tbody>
</table>

[Map of Florida showing demand served areas]
Generalized framework to analyze fuel distribution

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.

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.


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.14
Cooperative monitoring during crisis

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

Problem formulation and solution mechanisms: a behavioral study of humanitarian transportation planning.
Cooperative problem solving pre-crisis

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

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

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

Jarrod Goentzel (ctl.mit.edu/goentzel)
Ukraine Emergency
Situation Report #1
As of 01 March 2022

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:
  o Most Polish transporters are not willing to cross the border into Ukraine due to growing insecurity and inadequate insurance coverage.
  o 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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Questions

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