



Considerations about the Cascading Effects of COVID-19 on Critical Infrastructure Sectors

INTRODUCTION

Today, we are dealing with an unprecedented event in modern times with the spread of the Coronavirus Disease (COVID)-19 around the globe. Aside from just the numbers of those infected and mortality rates, a pandemic can result in damage across a number of areas that severely impact society. A nation's health, safety, and economy are dependent on an increasingly complex and interconnected set of infrastructure systems. This is especially true in technologically advanced nations, like the United States.

As the growing number of people who have contracted COVID-19 has peaked in some regions around the world, requiring massive amounts of medical attention and hospitalization, various national leaders have imposed shelter-in-place and quarantine orders to isolate large segments of the population to slow down or arrest the spread of the virus. We find this unfolding around us here in the United States. The isolation of large segments of society and removal of large numbers of people from normal daily work and business functions has an effect across many sectors. While the closures of schools, businesses and leisure activities would be a first-order action, this causes effects in other select critical functions and infrastructure sectors. The resulting cascading effect is unintended second- and third-order effects in other sectors.

As seen in past months and weeks in China, South Korea, Italy and other nations fighting the spread of COVID-19, long-lasting quarantines, factory closings and lowered production rates has also resulted in cascading effects in the global supply chain. In a recent survey by the Shanghai Chamber of Commerce, more than half of the 109 companies responded that they've already seen disruptions to their supply chains and almost all of them expect the same within the next month. Furthermore, another survey found 94% of Fortune 1000 Companies report their supply chains have already been affected in some way.¹ We have learned from and are applying these lessons learned.

COVID-19 has spread across the United States and there are now positive cases in all states. Governors have made Emergency declarations, closing down non-essential government services, businesses, schools and other functions and mass gatherings of people. This paper is offered in an effort to better understand not just the way a pandemic affects various critical infrastructure sectors, but to illustrate the cascading and escalating effects across our nation in various ways. Each of the following sectors lists observations and assumptions, along with current gaps in known information.

SECTOR ANALYSIS

Chemical Sector

- Fallouts from the supply disruption in China could affect the availability of raw material for the chemical industry during the first half of the year
- Notably, U.S. chemical makers procure many chemicals critical to their production processes from China so shutdowns due to the outbreak are likely affect the delivery of key raw materials
- Long-term chemical supply disruptions could also lead to a spike in costs of these inputs and eat into margins of chemical makers, with most of the impact expected to be felt in the March quarter²

¹ <https://www.pbs.org/newshour/economy/making-sense/novel-coronavirus-could-be-a-wake-up-call-for-companies-relying-on-china> (February 24, 2020)

² <https://www.nasdaq.com/articles/coronavirus-casts-a-pall-over-chemical-industry%3A-heres-how-2020-02-27> (Feb 27, 2020)

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Information Gaps

- It is yet to be determined if the unavailability of needed chemicals could shut down essential services from water purification through food production
- It is presumed that China provides 30% of the nation's drugs and pharmaceuticals and there is additional uncertainty regarding how long Chinese-based supplies will continue, considering rising tensions between the US and Chinese governments³
- Who, within the public and private sectors, is working to find alternate sources and diversifying our chemical supply chains?

Commercial Facilities Sector

- The United States has largely become a consumer society
- The cancellation of conferences, symposia and expositions leads to a loss of hotel, restaurant and convention center business and the lowered numbers of people traveling and vacationing will lead to losses of jobs in this area of the commercial facilities sector
- Much like the recent French decree to cancel events with over 1,000 attendees in order to slow down the spread of COVID-19,⁴ we now find State Governors imposing similar restrictions within the US and at much lower levels (500 to 250 attendees)
- Tourism industry will greatly shrink, and brick-and-mortar entertainment facilities and various commercial enterprises are already being impacted⁵
- Greater telework and home isolation will cause a shift away from restaurants and other brick and mortar establishments.
- Various public venues like theaters, concert halls, and shopping malls will be greatly impacted as more people self-isolate and employ more social-distancing⁶
- The cruise ship industry has taken a great economic hit and is basically closed down until the pandemic passes. Governors started asking companies to suspend operation as early as last week and by the end of the week, the US President was engaged with various companies⁷
- The gaming industry (\$250 Billion industry within the US) will lose money as professional sporting professions have cancelled tournaments, spring training and suspended seasons

Information Gaps

- How can Commercial Facility Sector organizations do a better job of informing public of preventative measures and regain public confidence?
- How might the pandemic restrictions on Houses of Worship affect the spirit and morale of the American public?
- How will the majority of workers in service-oriented society living paycheck-to-paycheck pay their bills and support their families?

³ https://www.theepochtimes.com/china-manufacturing-of-most-us-medicine-and-vitamins-poses-security-threat-researchers-say_2497862.html (October 8, 2018)

⁴ <https://www.ibtimes.com/france-bans-gatherings-1000-over-virus-two-more-mps-infected-2936203> (March 8, 2020)

⁵ <https://www.mercurynews.com/2020/03/02/coronavirus-hits-entertainment-industry-and-some-shows-may-not-go-on/> (March 2, 2020)

⁶ <https://www.hstoday.us/subject-matter-areas/infrastructure-security/1918-flu-sheds-light-on-how-covid-19-could-affect-critical-infrastructure/> (March 5, 2020)

⁷ <https://www.tampabay.com/news/health/2020/03/08/state-department-issues-warning-to-travelers-dont-take-a-cruise/> (March 9, 2020)

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Communications Sector

- Availability rates of systems could be affected by lack of minimally-required labor force necessary to maintain and run critical systems
- There is already a recognition that as more and more workers are told to tele-work and children are home from the closure of schools, that cell towers and whole systems could bottleneck, be overwhelmed and/or crash
- Considering that all of the people across the nation are now (at the same time) getting online for work, school and entertainment, specific usage may need to be prioritized (For instance, suspending non-essential and bandwidth-intensive services like streaming movies and gaming services during peak workday hours)
- The suspension of select services needs to be fully thought through as the public has become dependent on social media for communications and as the source of their news information
- Under emergency conditions, government authorities need to open up more bandwidth and/or frequencies for public use
- Short wave volunteer networks could be established and utilized throughout more rural environments

Information Gaps

- If more and more of the American workforce moves to tele-work, can existing infrastructure support the vastly increased usage?
- Can companies like Verizon and other providers do anything other than manage existing usage?
- How quickly can private sector providers reconfigure networks for additional bandwidth need and who makes those determinations?
- Who is going to pay the costs associated with reconfiguration and possible slowdown or loss of services?
- Will the regulators approve rate increases or should this be presented to the public as a general tax?'
- While State governments employ and use a Public Information Officers in times of crisis, should the medical spokesperson for the US be tasked with creating a highly credible, public-private COVID-19 national news bureau to efficiently push out up-to-date, evidence-based information to the American public?

Critical Manufacturing Sector

- Production will be affected by just-in-time supply chain of essential component parts and raw materials if current stockpiles are depleted
- Some production lines could slow down and/or close due to labor force unavailability
- Some key companies may need to get waivers to continue their work
- Under the Defense Production Act, the President can assume control over specific raw materials or manufactured components

Information Gaps

- How are specific companies recognized as "critical" in the manufacturing world?
- How much of Critical Manufacturing is interstate and international?
- Much States be in better collaboration to ensure interstate Critical Manufacturing is better coordinated?

Dams Sector

- Federal regulations concerning hydro-electric plants, requires specific numbers of critical personnel and safeguards
- System controls and maintenance could be affected by lack of workforce should a pandemic expand
- In addition to some of the nation's dams providing hydro-electric power generation, other dams control levies to safeguard communities and urban areas against flooding

Information Gaps

- What level of control and resources does the Army Corp of Engineers provide across the nation?

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Defense Industrial Base Sector

- The lack of parts for new weapons systems will slow down production lines (Lockheed Martin announced they are “pausing production” of a F-35 plant—Mitsubishi Heavy in Japan and another F-35 plant in Italy has employees staying home)⁸
- Lack of spare parts availability could eventually affect the US military’s weapons and force readiness levels

Information Gaps

- How dependent are the DIB and military bases on commercial energy?
- Have various states identified and working with single-source DIB companies throughout the US to better safeguard continued production?
- How might quarantining at specific bases effect wartime readiness?
- Could a pandemic slow-down or suspend large-scale construction at places like shipyards and aircraft factories
- What is the level of reserve stockpiles and critical components?

Emergency Services Sector

- As more and more cases develop, there’s a heavier and heavier load on the finite number of law enforcement, firefighters and EMT’s working throughout the nation.
- As Police, emergency medical technicians, and firefighters are stretched more thinly due to the spreading pandemic, plans need to be set on triaging calls.
- Products and supplies need to sustain the sector may be difficult to acquire – respirators, drugs, masks, rubber gloves, fuel, etc.⁹
- Ask non-government organizations and faith-based organization about support to on-duty Police, Fire and EMS units.
- Could develop a reserve corps and calls for recently retired volunteers, but knowing most of those might be older and fall into the higher at-risk category.

Information Gaps

- Can the six percent of FEMA money set aside for proactive mitigation instead be approved for emergency response for what is immediately needed during the pandemic?
- With the majority of Fire Departments and EMT’s across the nation composed of volunteer companies, how might personnel availability be a greater issue for the nation?
- Could active, guard and reserve military forces be called in for Emergency Services duty in the homeland?
- Like in Healthcare and Public Health, will front-line personnel in this sector require additional childcare support?

Energy Sector

- The worldwide refinery of petroleum could be impacted and logistics of moving fuel oil, diesel fuel, gasoline, and lubricants affected, which is likely to further exacerbate critical manufacturing and the defense industrial base.¹⁰
- Major reduction in aviation fuel consumption is expected as less people fly
- Bulk power providers should ensure they have appropriate level of key staff and plans for those cross-trained in areas requiring critical skills.

Information Gaps

- How do the coronavirus reactions (factories closing, less demand for travel, cancelled travel demands, worker shortages) come together to drop the demand for more oil and bleed into the current crash in oil prices?¹¹

⁸ <https://www.businessinsider.sg/coronavirus-causes-pause-f35-aircraft-work-in-japan-italy-2020-3>

⁹ <https://www.hstoday.us/subject-matter-areas/infrastructure-security/1918-flu-sheds-light-on-how-covid-19-could-affect-critical-infrastructure/> (March 5, 2020)

¹⁰ <https://www.hstoday.us/subject-matter-areas/infrastructure-security/1918-flu-sheds-light-on-how-covid-19-could-affect-critical-infrastructure/> (March 5, 2020)

¹¹ <https://qz.com/1814957/how-the-crash-in-oil-prices-is-playing-out-around-the-world/> (March 9, 2020)

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- How does the identification of multiple control systems and finite numbers of personnel certified to run these systems create a vulnerability during a pandemic?
- Will closed factories in China (and abroad) cause a slowdown in the Solar Energy movement?¹²
- Could special problems be exposed with coal production due to the labor-intensive nature of the process?

Financial Services Sector

- As already reported from other outbreak nations, there's a growing concern about the transmission of the disease from physical (paper and coin) currency
- As already seen here in the United States, increased testing, leading to the identification of dramatically more positive COVID-19 cases and State Governor declarations, has influenced Stock Market sell-off, as investors anticipate the coming loss of revenues in the consumer markets
- Every citizen who has investments in the Stock Market through various retirement accounts is feeling the affect of the economic slowdown as more and more businesses are shut down
- In this environment, electronic financial systems are critical and will be stressed

Information Gaps

- If financial institutions begin to close, how will people get access to their money?
- Do financial reporting and security requirements allow for tele-work of personnel in this sector?
- Do financial institutions have plans and procedures for money sanitization?

Food and Agriculture

- Specific products (mostly personal protection) have already been cleaned off shelves at stores and from online sources
- The food distribution systems do not lend themselves to social distancing and in some places (stores) social distancing is almost impossible
- Restaurants are closing in places. People without access to cooking (hotels, travelers) remain restaurant customers
- Food stores in Europe are remaining open and a reasonable assumption is that US food stores will remain open.
- Since food stores are gathering places of people, there is an immediate need for enhanced sanitization practices at stores (i.e., credit card readers and keypads should be wiped down after each use and cash purchases discouraged or prohibited)
- The trucking industry is required for the food industry to survive and truckers cannot tele-work and are potential carriers COVID-19 that will be moving freely throughout the nation
- Governments should immediately become familiar with food distribution centers and assist in the planning for their continued operations through a pandemic
- With school shutdowns, officials are considering how to feed kids dependent on their school meal programs
- Should a prolonged pandemic occur, key foods may go unplanted, unharvested, unprocessed and/or unpackaged due to workforce shortages
- In Italy, the rapid spread of the virus and resulting quarantines and travel restrictions have greatly impacted the agriculture sector—as other nations which import Italian agricultural products are now requiring additional certifications on food safety¹³
- There are no known animal hosts known or known conveyance of COVID-19 by pets or other animals
- Pork industry is looking at mitigating any supply chain issues
- Raw meat and unpasteurized milk could be a problem in spreading the virus

¹² <https://finance.yahoo.com/news/spread-coronavirus-cause-slowdown-solar-130000163.html> (March 6, 2020)

¹³ <https://www.oliveoiltimes.com/production/coronavirus-epidemic-hits-italys-agriculture-sector/80460> (February 27, 2020)

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- State Veterinarians are a good source of information on coronaviruses as they have been dealing with these for decades in animals

Information Gaps

- While the USDA website remains focused on USDA programs in a pandemic, are the majority of the US food systems being largely unaddressed?
- As more news develops about longer stay-at-home periods; closures of businesses and restaurants; how will the public and private sector address more food hoarding?
- How are state and local governments working with private sector to ensure food delivery should the trucking industry start to be adversely affected by the pandemic?
- Are trucking companies going to have food delivery truckers employ additional safe work practices (like masks and gloves when on-loading and off-loading) foods?

Government Facilities Sector

- Some services may be impacted due to loss of workforce and upkeep of essential services
- Key people who cannot do their jobs outside of their office and work environments need to be equipped and trained to use remote tools to tele-work
- Government entities should have Continuity of Operations (COOP) plans readied
- Before closing public K-12 schools and upper educational institutions, leaders need to consider the secondary and tertiary effects on the surrounding area workforce

Information Gaps

- How does the expansion of the virus, both in the US and globally, effect military readiness from availability of needed spare parts, supplies and support at our bases?
- Is the IT structure of key government agencies and the services they provide to the nation set up to support tele-computing from home offices?
- There are reports from other nations about the possible release of convicted criminals from prisons, due to the accelerated spread of disease across prison populations—do US Federal, State and local officials have plans and contingencies for dealing with this?
- Is the Strategic National Stockpile under-supplied to meet a pandemic?

Healthcare and Public Health Sector

- The nation's healthcare system of hospitals is mostly working at peak
- A sudden increase of COVID-19 patients will force many (most) hospitals past surge capacity
- Aside from increased patient load, the workforce pressure due to illness on the finite numbers of doctors, nurses and hospital staff will adversely affect capability
- The availability of essential supplies and equipment will be impacted by the pandemic
- Triage of services may mean most (of not all) minor or elective surgeries or procedures postponed or cancelled
- The US is partially reliant on China for the raw ingredients that go into several hundred drugs used in the US—three of those drugs are antibiotics including amoxicillin, doxycycline, penicillin—90% of these drugs' core components come directly from China.¹⁴
- New sources of medical equipment, supplies and drugs need to be established
- Hospitals need to have plans to quickly expand or create more bed space if current capability is overwhelmed by COVID-19 cases
- Crisis Standards of Care Framework needs to be updated to reflect changes in technology from when it was written to address the H1N1 ten years ago

¹⁴ <https://www.msn.com/en-us/health/medical/coronavirus-could-cause-a-shortage-of-common-medications-in-the-us/ar-BB10uAP1> (February 27, 2020)

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- A new system of systems approach needs to incorporate guidance and trigger points for the quickly growing COVID-19 pandemic
- Hospitals need to use Incident Command principles and ensure they integrate doctors and nurses in the planning processes
- Hospitals should ensure childcare is provided to enable parents who are essential doctors, nurses and staff with children home from closed schools can stay on-the-job and in-the-fight
- Staff must have comfort and confidence in the Personal Protective Equipment (PPE)
- Hospitals may be forced into providing temporary housing to the elderly and those who have pre-existing conditions
- Shift scheduling will be critical to mitigate burnout of overworked staff
- Clinical staff should work up to their capabilities, but taken off responsibilities of lesser importance or criticality

Information Gaps

- Not enough is yet known about specific COVID-19 treatment and care.
- Can Standards of Care be modified at the State and local levels to meet unique circumstances?
- Who maintains the Common Operating Picture Dashboards for knowing levels of hospital capacity across the states, regions or nation?
- Most hospitals normally run at “capacity,” so how is anticipated overflow being approached?
- Does a national emergency declaration need to be made so that the military’s healthcare and CBRN-trained personnel be deployed to assist with care and mitigation in a pandemic?

Information Technology Sector

- Lack of workforce may result in data centers not being maintained, resulting in IT function slow-downs or failures
- Tripwires need to be established throughout the industry to be able to forecast when IT services in specific areas will be overwhelmed
- Expanded BYOD by tele-workers will expose more cybersecurity concerns—already an instance of malicious spoofing of Johns Hopkins University coronavirus tracking website for malware
- A larger audience of web-based and teleconferencing services may require higher subscriber limits

Information Gaps

- Is the basic structure of IT systems robust enough to support great increases in tele-computing/work from home?¹⁵
- Will the impact of COVID-19 and need to focus on more robust existing services, slow down the national 5G rollout?

Nuclear Reactors, Materials and Waste Sector

- This highly-maintained and critically-regulated sector seems to be the most reliant and secure
- The FLEX Program provides backup and spare parts capabilities at two national warehouses across the nation

Information Gaps

- Does the fact that there are only two FLEX Program warehouses pose a risk?
- Do nuclear energy providers have established criteria on when site safety or security would be compromised from loss of skilled work force or personnel?
- Are there plans for securing properly certified and trained personnel in the wake of losses due to a pandemic?
- At what point are you at minimal safe staffing, before you have to shut down a reactor?
- Are the two spare warehouses in areas highly susceptible to a pandemic?

¹⁵ <https://redmondmag.com/articles/2020/03/04/prepare-it-for-coronavirus-pandemic.aspx> (March 4, 2020)

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Transportation Systems Sector

- Seemingly, all modes of transportation (air, land and sea) could be impacted by a loss of personnel as those driving and maintaining vehicles can NOT tele-commute and not easily replaced
- Maintaining control systems operated by the FAA, USCG, state and city DOTs, railroads, pipelines and public transportation is essential for the safe movement of all modes of traffic
- 79% of all commodities in the nation travels by motor freight, taking into account intermodal transfers with truck-rail and truck-maritime. Therefore, it is imperative that motor freight carriers be provided high priority measures to keep moving. This includes easing or removing hours of service, noise abatement and curfew limitations. The FMCSA has already made an Emergency Declaration allowing some of this to happen and some states have already provided motor carrier relief
- Truck repair parts are now in the critical goods supply chain and must be kept flowing to distribution points such as dealers, roadside truck stops and other heavy vehicle repair points
- All public transportation vehicles (airplanes, commuter trains and buses) must be regularly sanitized to help slow down the spread of viruses
- As overseas factories remain closed, activity at US ports will slow down or end causing, not just a drop in critical imports, but slowing down the entire US economy
- Some port terminals may shut down if COVID-19 cases are discovered. This has already happened in the Port of Houston
- Major reduction in aviation fuel as less people fly, but cancellation of flights probably leads to layoffs of pilots, mechanics, airport personnel and staff. Some airport tower operations have already ceased with airspace control being passed to regional TRACONS. This will result in reduced air traffic capability
- Governors should take charge of balancing public health restrictions against the need to keep supply chains operating

Information Gaps

- What level of personnel, communication and IT is required to ensure the continued, steady flow of needed fuels through the nation's pipelines?
- What level of personnel, communication and IT is required to ensure the continued operations across all seven modes of transportation?
- What is the status of the interstate truck stops critical to the continued movement of motor freight?
- Understanding that the Postal system was a key carrier of the Spanish Flu in 1918, how do we ensure the same system (and other carriers like FedEx, UPS, DHL and others that did not exist a century ago) isn't carrying COVID-19 and spreading it across the nation?
- Can the Bio Detection System put into place at US Postal Service in the wake of the Anthrax attacks in 2001, scan for COVID-19 on mail and packages across all delivery systems?

Water and Wastewater Sector

- Water and wastewater treatment plants are vital to the operations of all other sectors
- Systems need to ensure they have access to required power, parts, workforce and chemicals
- Water utilities need to exercise their Continuity of Operations (COOP) plans

Information Gaps

- As more people stock up on bottled water, can US-located companies keep up with demand?
- Do all plants have a 90-day supply of required supplies on site?

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CONCLUSIONS¹⁶

What is currently unfolding across our modern, interconnected world is a quick-spreading coronavirus pandemic at a scope and scale unseen in the last century. Based on how this virus has spread through other nations, the President of the United States and Governors across the country have taken quick, decisive action in the attempt to slow down the spread so as not to overwhelm the nation's healthcare and medical system. Saturation coverage by the news media, along with unprecedented information-sharing across social media platforms, has caused a higher level of awareness and some concern—as seen in the panic buying of food and supplies occurring across the nation.

While attention has largely been focused on the spread of the virus, panic buying and politics, what is largely being missed are the longer-term ramifications of this pandemic on the global supply chain and how this event will create ripple effects causing unrealized and unaddressed issues across all areas and facets of our modern society. This paper's intent was to shed light on the cascading secondary and tertiary effects of workforce availability and product/supply shortages across the DHS-identified critical infrastructure sectors.

In general, the conclusion reached through many hours of discussions with subject matter experts across the nation, has been made clear to us. Most all of the cascading effects of COVID-19 across the nation's critical infrastructure sectors, can be focused on a couple key areas—workforce availability, supply chains and partnerships. Much like the basic guidance for preventing the spread of the virus is somewhat simplistic—washing hands and maintaining social distancing—the same can be said for identifying, forecasting and getting ahead of the longer-term cascading effects on society.

More specifically, these three main areas of focus should be on:

1. Identifying and taking action to ensure the nation has the personnel identified who can provide essential services and maintain the production of critical materials across the nation;
2. identifying our most critical supply chains, ensuring the supply of current over-demands and forecasting what supplies will be needed for future sustainment and continuity of operations; and
3. developing and maintaining the public/private sector partnerships to form solutions for evolving issues in the prior two areas.

While DHS CISA and the analytic might of internal organizations like the National Mitigation Risk Center are being applied to find answers and solutions to the evolving second and third-order effects from the pandemic to our society, the contributions of the private sector and organizations like the National InfraGard NDRC are vital. The NDRC should lead the effort to also pull together the intellectual power of InfraGard's Sector Chiefs and the knowledge resident across its 60,000+ members aligned with 77 chapters across the nation.

We know that across the spectrum of issues and effects laid out across the nation's 16 critical infrastructure sectors addressed in this paper, we have missed or don't have the most accurate complete picture. As this pandemic unfolds, there will be many more considerations that can be identified. If you have any input or comments based on your own expertise or knowledge, please contact Frederick Ferrer at FrederickFerrer@comcast.net. Additionally,

¹⁶ This paper has drawn on the knowledge and experience of members of the National InfraGard's National Disaster Resilience Council and Sector Chiefs. It is being led by Frederick Ferrer, who is a former InfraGard Chapter President, Regional Rep and National Board Officer. Mr Ferrer is also a member of the DHS State, Local, Territorial and Tribal Government Coordinating Council and a leader and member of various DHS Critical Infrastructure Partnership Advisory Council working groups.

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For more information on the National InfraGard program (including information on how you can join), go to <http://www.infragardmembers.org/>

For more information on the InfraGard's National Disaster Resilience Council, contact Mary Lasky at Mary.Lasky@jhuapl.edu