COE Initiative on the COVID-19 Supply Chain

Final Report

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CCICADA
Command, Control, and Interoperability Center for Advanced Data Analysis

Final Report on the COE Initiative on the COVID-19 Supply Chain

1. Background and Outcomes

This project formed the *COE COVID-19 Supply Chain Initiative* to bring together the expertise of the DHS Centers of Excellence (COEs) to address critical supply chain problems that emerged during the pandemic and to identify lessons that help prepare us for future disasters.

The Initiative aims to:

- Identify existing tools and technologies that might assist with the current pandemic;
- Identify key lessons learned from the current situation that will prepare our supply chains better for future disasters;
- Identify the need for research on new tools and technologies that will help us be better prepared for future disruptions of all kinds;
- Inform S&T and DHS components about the relevant expertise at the COEs; and
- Strengthen relationships among COEs and build awareness of expertise and synergies among them with the aims of:
    - Creating opportunities for serious collaborations among multiple COEs
    - Exploring joint research challenges that the COEs have the expertise to help with.

The coronavirus pandemic disrupted supply chains worldwide and revealed vulnerabilities on a scale never before witnessed. From shortages of personal protective equipment (PPE) to empty grocery store shelves, we saw firsthand the fragility of global supply chains.

- The initial spike in COVID-19 cases highlighted nationwide shortages of ventilators, test kits, masks, and other PPE, provoking competition between state and federal agencies and forcing us to rely on foreign sources for critical supplies.
- Outbreaks in meat packing plants threatened the food supply, as did mismatches between supply and a reconfigured demand for food. As demand moved from places of business to grocery stores and food pantries, there were reports of crops being plowed under, eggs being smashed, and milk being poured out. At the same time, lines for food support grew.
- As people were instructed to use hand sanitizer and other disinfectants, these products quickly disappeared from grocery shelves. Toilet paper, pasta, and yeast soon followed.

Establishing coherent national policies for acquiring, stockpiling, and distributing vaccines, PPE, medicines, and other critical supplies remains a challenge to surmount as we combat the current pandemic and prepare for future pandemics and other disasters. Healthy supply chains assure reliable flow of the raw materials, components, and end products that are essential for the economic security of our country, the smooth functioning of government, and the well-being of society as a whole.

Keeping critical supply chains functioning is, therefore, important to DHS, and the DHS COEs have a significant role to play. The COE COVID-19 Supply Chain Initiative was formed to help define that role. The Initiative is led by CCICADA with collaboration from the Center for Accelerating Operational Efficiency (CAOE) and assistance from eight other COEs to organize workshops and other collaborative activities. Three additional COEs participated in the workshops by providing speakers. These 11 COEs and their roles are listed in Table 1.

ADAC	Arctic Domain Awareness Center	OC, WS, WP
ALERT	Awareness and Localization of Explosives-Related Threats	OC
CAOE	Center for Accelerating Operational Efficiency	OC, WS
CBTS	Cross-Border Threat Screening and Supply Chain Defense Center of Excellence	OC, WS, WP
CCICADA	Command, Control, and Interoperability Center for Advanced Data Analysis	OC, WS, WP
CEEZAD	Center of Excellence for Emerging and Zoonotic Animal Diseases	WS, WP
CINA	Center of Excellence for Criminal Investigations and Network Analysis	OC, WS, WP
CIRI		WP
CREATE	Center for Risk and Economic Analysis of Terrorism Events	OC, WS, WP
FPDI	Food Protection and Defense Institute	WP
NCITE	National Counterterrorism Innovation, Technology, and Education Center	WP

Table 1: Roles of COEs in the COVID-19 Supply Chain Initiative.
Key: OC = Initiative Organizing Committee, WS = Workshop Organization, WP = Workshop Speakers

The Initiative began with the plan to organize two workshops bringing together participants from the COEs, government agencies, and the private sector to learn from key stakeholders in industry, nonprofits, and state, local, and federal agencies.

Ultimately, the Initiative held seven very successful online workshops. Each was attended by more than 50 participants—with the final three exceeding 100—and each included numerous presenters from highly relevant private sector institutions and government agencies. We offer a few highlights in Section 1.1.

Plans for the initial workshops built on discussions at a virtual meeting held on May 12, 2020 that included participants from DHS University Programs and seven COEs—ADAC, ALERT, CAOE, CBTS, CCICADA, CINA, and CREATE. The primary goals of this meeting were to discuss the relevant expertise of each of the seven COEs and develop plans for follow-on events. Discussions following the meeting led topics for the first four workshops, and subsequent discussions and events led to definition of three more. The workshops held are listed in Table 2.

Date	Workshop	Coordinating COEs
8/21/20	Enhanced Supply Chain Crime During the Pandemic	ADAC, CCICADA, CINA
8/21/20	Supply of Labor During the Pandemic	CAOE, CCICADA, CREATE
8/27/20	Food Supply Chain During the Pandemic	CAOE, CBTS, CCICADA
8/27/20	Supply Chains for Medicines, Vaccines, PPEs During the Pandemic	CCICADA
1/7/21	COVID-19 Vaccines: Efficacy & Safety	CCICADA, CEEZAD
1/8/21	COVID-19 Vaccines: Distribution & Prioritization	ADAC, CCICADA, CEEZAD
6/21/21	Suez Canal Incident: Impact and Implications for the Global Maritime Supply Chain	ADAC, CCICADA, CREATE

Table 2: Workshops held as part of the COVID-19 Supply Chain Initiative.

For each workshop, we prepared a detailed summary report. Each report was fully reviewed by the speakers, organizers, and DHS and then posted to the CCICADA website. These summaries form the basis of the major sections of this report. They highlight the supply chain issues, challenges, and lessons learned that were discussed during the workshops and offer some strategies and tools for mitigating impacts. Full speaker bios are provided in the Appendix (Section 9) of this report.

1.1. Workshop Highlights

From a supply chain perspective, the pandemic has been an evolving crisis. As issues such as PPE shortages abated, new challenges—most notably the wide-scale manufacturing and distribution of vaccines—emerged. The long duration of the COVID disruption also saw the supply chain respond to overlapping shocks, such as the Suez Canal incident and the widespread power outages in Texas in March 2021. The project, in turn, added new workshops to explore emerging COVID-related challenges to supply chains.

Each workshop featured speakers with front-line knowledge who were eager to share their experiences and perspective with DHS and the COEs. These experts represented industry, nonprofit organizations, and academia, as well as local, state, and federal government agencies, including several areas of DHS. The COEs were also well-represented among the speakers. In addition to the COEs organizing the workshops, CCICADA, CEEZAD, CINA, CIRI, CREATE, FPDI, and NCITE also provided speakers.

In this section we present a few brief highlights from each workshop to provide a sense of the breadth and depth of participation. The bios provided in the Appendix (Section 9) and the workshop summaries that follow (Sections 2-8) offer a fuller sense of the expertise marshalled for these events.

The August 2020 *Workshop on Enhanced Supply Chain Crime During the Pandemic* (Section 2) explored two major threads: 1) criminal activity that sprung up to exploit the pandemic (often online) and 2) the special challenges faced in remote areas that led to greater opportunity for crime and difficulty in enforcement during the pandemic. On the first topic, we heard from Jere Miles of DHS Homeland Security Investigations who spoke about such issues as sale of counterfeit supplies and PPE, theft, price gouging, and hoarding during the pandemic. Among the speakers addressing the second topic was Mike Duxbury, retired State of Alaska Deputy Commissioner for Public Safety. He spoke about the vulnerability of remote areas and how the pandemic heightened crime in such regions by making them effectively even more remote and fragile. Also speaking was Agent Jack Staton of DHS Customs and Border Protection.

The August 2020 *Workshop on Supply of Labor During the Pandemic* (Section 3) considered issues of workplace safety and the potential economic costs of workforce issues. William Spriggs, a Howard University professor and Chief Economist to the AFL-CIO, explained that, for people of color, COVID-19 is a workplace issue. John Dony of the nonprofit National Safety Council (NSC) described resources the NSC was making available to make workplaces safer. Capt. Andrew Tucci (USCG, ret) described the impact of the pandemic on the maritime workforce and wondered whether the pandemic might accelerate the development of automation in the marine transportation system. Tony Cheesebrough, Chief Economist for DHS CISA, described a CISA study carried out by Victoria University in Australia projecting that COVID-19 would reduce US GDP and employment by more than 12% over the year 2020.

The August 2020 *Workshop on the Food Supply Chain During the Pandemic* (Section 4) showcased the work of government agencies and nonprofits working together and separately to

combat hunger and protect the food supply—work that was of heightened importance during the pandemic. A panel on Hunger Relief featured Blake Thompson of Feeding America, Katie Nye of the Texas Hunger Initiative, and Kevin King of the New York State Department of Agriculture. Together, they laid out the deep and immediate impact of COVID-19 on food insecurity, described how traditional distribution channels became inoperative, and illustrated innovative new partnerships that formed in response. A second panel on Food Supply Chain Vulnerabilities included panelists from both the USDA and FDA who described mechanisms for cross-sector collaboration during a crisis. John Hoffman of the Food Protection and Defense (FPDI) COE pointed out that cyber threats to the food sector have grown during the pandemic, and the sophistication of attackers and the poor state of cyber defense in the food industry creates a significant strategic risk to the US—a timely prediction in light of the June 2021 cyber attack on the meat giant JBS.

The August 2020 *Workshop on Supply Chain for Medicines, Vaccines, PPEs During the Pandemic* (Section 5) featured a panel on vaccines and another on medicines and PPE; both had robust industry representation. Karin Shanahan is Senior Vice President of Global Biologics and Sterile Operations at Merck, where her portfolio includes responsibility for supplying vaccines, such as Gardasil. As part of the Panel on Vaccines, Shanahan described a typical vaccine development process in contrast with the race for a COVID vaccine that was underway. She noted that the scale of the vaccination effort was unlike anything previously attempted. Also on the panel was Joe Lewis, who leads Deloitte's US Life Sciences Supply Chain COVID response programs and stressed the need for transparency and trust during the pandemic. The second panel included Rory Yanchek, a Vice President at 3M, a leading manufacturer of PPE. Yanchek described innovative ways that 3M was collaborating with other companies and with government to ramp up production of PPE and other medically necessary products. Government perspective was also well-represented by Daniel Gerstein, former Acting Under Secretary and Deputy Under Secretary of DHS S&T (now with RAND), and by Brian Weinhaus from ICE-HSI's Operation Stolen Promise, who described a range of COVID-related fraud being uncovered. William McLaury, a retired executive from Novartis, discussed threats arising from potential shortages of medical glass vials and stoppers that are sourced primarily from suppliers in China, potential shortages of stoppers since a few manufacturers dominate the stopper business, and potential issues with foreign sources of raw materials and chemical ingredients needed to produce vaccines.

The January 2021 *Workshop on Vaccine Efficacy & Safety* (Section 6) featured experts from the companies that were most in the news—Pfizer and Moderna. Workshop attendees learned about the very latest vaccine trial results from Dr. Philip Dormitzer, leader of Pfizer's viral vaccines research and development programs, and from Dr. Randy Hyer, Senior Vice President for Global Medical Affairs at Moderna. They shared safety and efficacy data, showed the approximate timing of protective immunity, and drilled down to discuss vaccine efficacy in several subgroups of interest. Dr. Karen Makar of the Bill & Melinda Gates Foundation described the outlook for vaccines reaching low and middle income countries and noted the Foundation's concern that inequality in vaccine distribution was a looming global threat and a focus of the Foundation's efforts. Also speaking was Dr. Hana Golding of the FDA. She described the licensing and approval process for vaccines, with a special emphasis on the Emergency Use Authorizations granted to Pfizer and Moderna. Taken together, the speakers in this workshop provided an end-to-end view of the vaccine development process, the wide range of vaccines under development, the potential risks of vaccine-induced mutation, and the global scale of the vaccination effort.

The January 2021 *Workshop on Vaccine Distribution & Prioritization* (Section 7) included a compelling mix of presenters involved in vaccine distribution from many different vantage points. Marion Whicker, Deputy Chief of Supply, Production, and Distribution for Operation Warp Speed offered an overview of the federal government's streamlined process for distributing vaccines to end-use locations. Dr. Kevin Ban, Chief Medical Officer at Walgreens, represented one of those end-use locations. He spoke about Walgreens' partnership with Operation Warp Speed to administer vaccines to residents of long-term care facilities and their plans to assist in vaccinating the general population. Reggie Jackson, Senior Manager of Supply Chain Security at Pfizer, talked about security measures the company put in place to determine the location of its vaccine shipments and receive a warning whenever a shipment deviates from its pre-set route. With the vaccination rollout still just beginning, Dr. David Adinaro, Deputy Commissioner of Public Health Services in New Jersey, described the plans for vaccine distribution in New Jersey built around a mix of mega-sites, hospitals, county health facilities, physician's offices, and retail pharmacies. Finally, Shellie Martin, a community health aide with the Kodiak Area Native Association (KANA), offered unique perspective on vaccine distribution to the nation's farthest reaches. Martin travels between five remote villages in the Kodiak archipelago administering vaccines to native populations.

The June 2021 *Workshop on the Suez Canal Incident: Impact and Implications for the Global Maritime Supply Chain* (Section 8) explored the impact of a maritime event in the context of another disruption—that of the pandemic. Speakers discussed the potential threats from the unexplored impacts of multiple, overlapping disruptions such as natural disasters, cyber attacks, and labor stoppages. The workshop featured a keynote address by Rear Admiral Brian Penoyer of the US Coast Guard. Speaking from extensive experience, he described congestion at West Coast ports as economies emerged from the pandemic, discussed the Coast Guard's role in bringing ashore and treating cruise ship passengers with COVID, and presented several ideas about resilience in maritime transport systems and the supply chain more broadly. The panelists who followed collectively represented decades of experience overseeing some of the nation's largest ports and waterways, as well as some of its most remote. They included Sam Ruda (Director) and Bethann Rooney (Deputy Director) of the Port Department of the Port Authority of New York and New Jersey, the nation's third largest port, as well as Coast Guard Capt. Zeita Merchant, Commander of USCG Sector New York. The Port of Long Beach and the Port of Los Angeles together comprise the busiest port complex in the U.S. Representing that port complex was Casey Hehr, Director of the Security Division at the Port of Long Beach. The participants pointed out that while the Suez Canal incident had relatively minor impact, it could have been much worse, and discussed some of the scenarios that are of concern.

1.2. A Note on Participation & Outcomes

1.2.1. Significant Participation from Government and the Private Sector

We did not collect data on who actually attended the workshops online, but based on counts, most of the people who registered did ultimately attend. The number of people registered ranged from the low 80s to 170, while the number attending online ranged from the mid-40s to over 130. The institutional mix of the people who registered demonstrates broad interest in the topics, including strong participation from DHS, other government agencies, industry/nonprofits, and academia, as summarized in Table 3.

Workshop	DHS	Other Govt	Private Sector	Academia	International (non-univ.)	Total
Enhanced Supply Chain Crime	43	7	5	26	-	81
Supply of Labor	34	8	6	18	-	66
Food Supply Chain	48	11	9	26	-	94
Medicines, Vaccines, PPEs	44	8	9	20	-	81
Vaccine Efficacy & Safety	56	16	25	64	5	166
Vaccine Distribution	57	17	27	64	5	170
Suez Canal Incident	26[1]	24	18	23	7	98[2]

Table 3: Summary of affiliations of registered participants for each workshop.

Our workshops included DHS participants from USCG, FEMA, CBP, ICE-HSI, CISA, Office of the DHS Chief Medical Officer, and Intelligence & Analysis, among others. Clearly there is great interest in lessons learned from the pandemic and ways in which different components of DHS might approach future disasters. In addition to DHS, the workshops have involved participants from BARDA, HHS, USDA, FDA, DOJ, DOD, DOT, state and local homeland security, health, and agriculture departments, and others, in recognition of the cross-disciplinary issues involved in the pandemic and the need for cross-government collaboration in addressing disasters of various kinds.

There has also been extensive participation by representatives of the private sector, including Deloitte, 3M, Merck, Pfizer, Moderna, Walgreens, Johnson & Johnson, Anneal Initiative, Chronicled, Modern Technology Solutions, Seebald & Associates International, and others. Involvement of key private sector representatives and industry groups such as the Institute for Supply Chain Management and Business Executives for National Security (BENS) in this initiative will key private sector collaboration with DHS on these critically important problems. Indeed, as we have discussed and designed follow-up projects, security directors from such companies as Merck, 3M, Johnson & Johnson, and tool developers from such companies as Chronicled, have agreed to continue working with us on specific projects. Our workshops have also had extensive participation from nonprofits, including National Safety Council, Feeding America, Texas Hunger Initiative, International Food Policy Research Initiative, Gates Foundation, Air Forwarders Association, Alaska Native Tribal Health Consortium, and AFL-CIO.

The two vaccine workshops included registrants from not only the companies mentioned above (Pfizer, Moderna, Merck, J&J, Deloitte, and Walgreens) but also from Walmart, US BIOLOGIC, INDICAL Bioscience, Parsons, and the Mexican pharmaceutical company Avimex. It also

[1] Many DHS participants joined at the last minute and had not pre-registered, so this number is certainly lower than the real number of participants.
[2] Online participation was observed to be higher than this.

included nine registrants from the USDA, as well as representatives from the National Cattlemen's Beef Association, National Pork Board, National Grain and Feed Association, Swine Health Information Center, and the Kansas Department of Agriculture. This level of diverse representation exceeded expectations and made for an engaging event.

As another example, the workshop on the Suez incident featured especially strong interest from the government sector. Not only were there a large number of participants from the US Coast Guard, but there were also registrants from the US Army, US Navy, and US Air Force, as well as from the British Royal Navy and several from the Canada Department of National Defense. Other parts of the US government were also well represented with several registrations from the USDA, DOT, and United States Arctic Research Commission, as well as from HHS, NOAA, and FBI. Adding to this were registrations from the Royal Canadian Mounted Police, Port Authority of NY & NJ, Amazon, Booz Allen Hamilton, Pfizer, and the Fairbanks Economic Development Corporation, among others. The spectrum of stakeholders expressing interest was impressive.

As a result of the workshop series, Beth Jones of CAOE and Fred Roberts of CCICADA were invited to join an activity of BENS, namely a BENS Commission on the National Response Enterprise aimed at identifying lessons learned from the pandemic that would focus us on future disasters. Jones and Roberts joined the Supply Chain working group and participated in developing recommendations that were passed on to the Commission's leadership, which includes former DHS Secretary Jeh Johnson.

In July 2020, the workshop series caught the attention of then-DHS Chief Medical Officer Duane Caneva and led to a vibrant exchange of ideas. One outcome was that CCICADA Director Fred Roberts was invited to help organize programs as part of the initiative called Clean Summit. This series of five workshops, which had the heavy involvement of Dr. Caneva, brought together leaders from industry, government, and universities to address the urgent need for solutions as America returned to work and school, and the physical and operational challenges this imposed. It addressed ways to secure the safety of our indoor spaces as a key challenge to ending lockdowns, reopening the American economy, and "returning to normalcy." Roberts helped organize the fifth Clean Summit, held on December 8, 2020, which was concerned with "Confidence in PPE - Science and fidelity of PPE supporting healthy workforce and workplaces." As part of that meeting, he organized a private sector panel that included representatives of the Institute for Supply Chain Management, VectorCSP, 3M, McKesson Medical, and Exiger, LLC. In turn, this has led to continued involvement with a consortium to bridge science with real-world operational situations at the nexus of buildings, people, and pathogens – a topic that is much broader than the original emphasis on COVID.

1.2.2. COE-COE Collaborations

Significant COE-COE collaborations have resulted from the workshop series. Many of these are informal, and consist of invitations to speak at other events, or communication about research challenges. However, a number have led to the design of new research initiatives and the development of white papers and proposals. Here are some examples:

- *Disruptions of Supply Chains by Criminal Organizations*: A new CINA-CCICADA project that is slated to begin soon.

- *Workplace Safety*: A collaboration among CAOE, CREATE and CCICADA on understanding how to make workers feel safe going back to work during COVID with special emphasis on federal workers such as at TSA.
- *Training Intelligence Analysts*: A collaboration among CINA, NCITE, and CCICADA on best practices.
- *Vaccine Hesitancy*: A joint activity of CCICADA and CREATE on understanding why different groups are vaccine-hesitant, developing messaging to help people decide about vaccines, identifying best media for messages, and measuring economic and public health impact of successful vaccine messaging.
- *Complex Disruptions to the Maritime Supply Chain*: A collaboration between CCICADA and CREATE to identify new tools for the development of models to understand the cascading impacts of multiple, overlapping disruptions such as hurricanes, cyberattacks, vessel groundings, etc.
- *Mitigation Strategies for COVID-19*: A collaboration between CEEZAD and CCICADA that included a Summit panel on diagnostics, therapeutics, and vaccines.
- *Network Discovery from Data*: A collaboration among CINA, NCITE, START, and CCICADA that included a Summit panel on discovering criminal networks.

1.2.3. Research Challenges

Each workshop gave rise to new research questions about how to address future disasters. The most recent workshop on the Suez Canal incident is a case in point. Among those challenges raised are:

- Things could have been worse with different tides and could be much worse if such a blockage occurs in the context of a cyberattack or a hurricane, a labor stoppage or another major disruption. Such complex, multiple, interacting disruptions are much more complicated than single ones. Research is needed on examples of complex disruptions, their impacts, the ones posing the most risk, and potential countermeasures to prevent them, prepare for them, respond to them, and recover from them.
- Before the pandemic, supply chains had become very efficient because of "just-in-time" technology. In the wake of large-scale disruptions during the pandemic, shippers and merchants ramped up shipments "just-in-case" of future shutdowns. Research is needed to study whether we will fully revert to "just-in-time" and whether we should.
- Unusual events can be "predictable" but only to the extent that government agencies and others share information on how an incident is being managed, allowing industry to make alternate plans. In the Houston Ship Channel, for instance, the Coast Guard cannot promise to always keep the passage open, but it has been able to limit closures to no more than five days. Modern modeling systems used to manage today's supply chains can take such levels of delay into account. Research is needed on how to make unusual events predictable.
- The Suez Canal incident had relatively minor short-term impacts on particular US ports. This doesn't take into account the possibility that indirect effects may linger and ultimately have larger and longer-term economic and supply chain impacts. For instance, most of the traffic through the Suez Canal from Asia is destined for Europe, not the US. What we need to investigate is whether delays in supplies headed to a port like Rotterdam have downstream impacts in the US when those supplies are needed to

produce goods that are later shipped to the US. Research on such cascading impacts is needed.

- The study of maritime disruptions should not be limited to the study of individual ports and vessels. Research should consider system interconnections. It should consider chokepoints in connecting rail networks, failures in nearby smart traffic signals and emerging autonomous technology used near a port, and disruptions of emerging communications technologies that could impact trains and vessels.

2. Workshop on Enhanced Supply Chain Crime During the Pandemic

In the early stages of the coronavirus pandemic, the FBI and Secret Service issued a press release detailing the potential for dramatic increases in novel types of crimes that could arise.

> *"Swindles, scams, and outright thefts have long been a feature of major disasters. The more catastrophic the event, the more active the fraudsters. However, the COVID-19 pandemic provides criminal opportunities on a scale likely to dwarf anything seen before. The speed at which criminals are devising and executing their schemes is truly breathtaking."*
> *FBI/Secret Service press release*

These types of concerns led Dr. Jim Jones, Director of CINA, Maj Gen, USAF (Ret) Randy "Church" Kee, Executive Director of ADAC, and Dr. Fred Roberts, Director of CCICADA, to organize the *Workshop on Enhanced Crime During COVID-19*. It was held on August 21, 2020 and organized around two panels—*Crime in Licit and Illicit Supply Chains* followed by *Rural Crime and Crime in Remote Areas*.

It was not long into the pandemic before the FBI's warnings began to be realized with a variety of fraud and criminal activity that included:

- Drugs marketed as "cures" or vaccines for COVID-19;
- Counterfeit N95 masks, gowns, gloves, and other PPE;
- Cyberattacks on the supply chain;
- Illegal hoarding and price gouging; and
- Fraud against the CARES Act.

These were among the topics of the workshop's first panel on Crime in Licit & Illicit Supply Chains. The second panel on Crime in Rural & Remote Areas explored ways that COVID-19 exacerbated the already high levels of risk and vulnerability that remote regions face even during normal times.

2.1. Panel on Crime in Licit & Illicit Supply Chains

Panelists:

- Kerry Bernstein, Principal Scientist, Modern Technology Solutions, Inc.
- Jere Miles, (Acting) Assistant Director, Operational Technology and Cyber Division, Homeland Security Investigations (HSI)
- Randy Sandone, Executive Director, Critical Infrastructure Resilience Institute (CIRI), a DHS COE at the University of Illinois

- Dr. Louise Shelley, Omer L. and Nancy Hirst Professor of Public Policy and University Professor, George Mason University

The Panel on Licit and Illicit Supply Chains was moderated by Jim Jones.

"This pandemic is basically a feeding frenzy for organized crime. We see a growth in every kind of organized crime that we're talking about." Louise Shelly, CINA COE

Louise Shelley said that the pandemic has produced a "feeding frenzy" for transnational crime. There has been a growth in every type of transnational crime: online fraud, calls intended to defraud individuals, and sale of counterfeit goods needed for protection during the pandemic. This "ecosystem" could not have been developed this rapidly without attaching itself to the already existing pharmaceutical counterfeit ecosystem. According to Shelley:

- Drug supply chains were disrupted, but drug problems continued unabated, and opioid deaths grew despite the disruption of supply chains for narcotics;
- Human trafficking flourished online and in the streets; and
- Environmental crime, such as poaching, timber theft, etc. increased globally.

Shelley said that these crimes were being committed by both state and non-state actors. In order to combat them, we need to be doing much more network analysis and large-scale data analysis to understand who is facilitating the online sale of narcotics, the sale of counterfeit PPEs, etc. Several speakers on both panels spoke about the ability of transnational criminal organizations to change rapidly to exploit COVID.

Randy Sandone warned that cyber criminals were developing and boosting their attacks at an alarming pace. These included:

- Increasing numbers of phishing attacks using COVID as a lure;
- Malware related to COVID;
- Attacks on pharmaceutical companies, research labs, academic institutions, and individuals;
- Increasing attacks on individuals forced to work at home with little preparation and weak network security; and
- Stealing people's credentials when they access their coronavirus relief account.

Sandone argued that technology such as Artificial Intelligence, Machine Learning, and Natural Language Processing can be key contributors to more efficient and resilient modern supply chains, but since they depend upon cyber systems their value can be undermined by cyberattacks on those systems. Just-in-time scheduling has made supply chains efficient but vulnerable—pulling even one supplier offline can lead to a disruption of the entire supply chain.

Jere Miles described some of the areas where law enforcement can use help:

- When counterfeit PPE is sold over the Internet, how do we find who is manufacturing it?
- How do we detect hoarding and price gouging early?
- Theft from legal supply chains exacerbates shortages. This is usually handled at the state level, but it can be interstate commerce, and new tools would help identify such cases. How can we determine whether organized crime is playing a role?

With specific emphasis on counterfeiting in electronics and micro-electronics (an area where 30% of the supply is counterfeit or cloned), Kerry Bernstein, a consultant developing hardware security technologies for the DoD, talked about the availability of and need for:

- Tools for understanding where a counterfeit part came from;
- Ways to use social networking to expose counterfeit networks; and
- Ways to test any component onsite.

US law enforcement intercepted COVID-19 "treatment kits" bound for California and Utah

Source: https://www.ice.gov/news/releases/british-man-charged-shipping-mislabeled-and-unapproved-treatments-patients-suffering
Photo credit: ICE

2.2. Panel on Rural Crime & Crime in Remote Areas

Panelists:

- Shannon Jenkins, Senior Arctic Policy Advisor to the Commandant, U. S. Coast Guard Headquarters
- Dr. Whitney Lackenbauer, Canada Research Chair in the Study of the Canadian North and a Professor in the School for the Study of Canada, Trent University
- Mike Duxbury, State of Alaska Deputy Commissioner for Public Safety (retired)
- Agent Jack Staton, Deputy Director, Joint Task Force West, U. S. Immigration and Customs Enforcement, DHS

"A small change can have significant impacts on stability. Decreased stability can lead to increased criminal activity and temptation." Shannon Jenkins, USCG

The Panel on Rural Crime & Crime in Remote Areas was moderated by Church Kee.

Mike Duxbury discussed the lack of infrastructure and redundancy in remote regions such as those in parts of Alaska. The pandemic, he said, highlighted the fragility of the system. It exacerbated the lack of services and left people even more vulnerable. Whitney Lackenbauer pointed out the high cost of services in such regions. The demand price for legal drugs has increased, and there are shortages. Making rural supply chains more resilient is a major part of what Canada hopes to accomplish in such regions.

Lackenbauer spoke about the importance of information sharing to gain domain awareness and enhance coordination, while Shannon Jenkins pointed out the challenges with engaging with communities and overall domain awareness by the Coast Guard as a result of the pandemic. If the Service isn't present, then that opens the door for potentially illicit activity.

Several panelists spoke about the reduction in law enforcement activities, in part, because of health concerns and, in part, because of infrastructure challenges. This, in turn, exacerbated problems with crime. Lackenbauer and Duxbury mentioned ways in which COVID heightened crime in the region:

- Domestic violence and sexual abuse—already high in remote areas—increased;
- Continued narcotics trafficking despite dramatic rises in price (methamphetamine and heroin prices doubled or even tripled in some areas); and
- Increases in illicit fishing and wildlife trade.

In remote regions of Alaska or Canada's Northern Territories, transportation of people and goods is primarily through the maritime transportation system (MTS) or small air carriers. Jenkins pointed out that rural Alaska, with few roads and dependence on the MTS, encountered challenges and additional stressors due to the pandemic. One example was that crews on vessels were restricted from going ashore to facilitate the transfer of cargo and fuel. In one instance, this directly led to a fuel spill. These are the types of additional stressors—disruptions in the flow of stability within the communities—that foster opportunities for criminal activity, both from internal and external sources.

Duxbury observed that during COVID, air cargo, parcels, and products carried on vessels were more vulnerable to crime. (For approximately 2 months at the peak of the crisis, interdiction activity that involved search warrants was shut down for fear of COVID exposure.)

Duxbury also pointed out that because of COVID, a major rural air carrier in Alaska, RavnAir, went bankrupt, and shortages of air transportation made it difficult to get domestic violence and sexual assault victims out of remote rural villages to services and treatment. It was also difficult to get criminal suspects out to court. Court personnel reductions limited the number of hearing trials and remands, leaving criminal suspects free to commit further crimes. Whitney Lackenbauer also spoke about the decrease in air traffic in the Northern Territories due to COVID, resulting in more food, fuel, and equipment being transported by ship, thus increasing the opportunity for crimes against shipping.

Agent Jack Staton said that as of this past July, illicit migration has returned to pre-COVID levels and there has been an increase in narcotic, money, and ammunition seizures along the southwest border. Staton said that even though COVID-19 negatively affected economies on both sides of the border, transnational criminal organizations do not appear to have been impacted in the same way. The increase in seizures does not necessarily indicate an increase in criminal activity, but could represent a higher number of inspections along the southwest border due to a decrease in non-essential traffic.

3. Workshop on the Supply of Labor During the Pandemic

As we quickly discovered, the supply of labor is disrupted during a pandemic:

- Some people were unable to work because their children were at home;
- Some workplaces saw disruption and reduced capacity because of social distancing requirements;
- Other workplaces (such as meat packing) were affected by having a large number of employees fall ill;
- Some workers were afraid to return to work because of concerns about workplace safety exposure or contracting the virus and bringing it home to their children or at-risk elderly parents;
- Teleworking enabled a great many to continue to work while in lockdown—is this likely to continue after COVID?

COVID-19's widespread impact on labor led Dr. Adam Rose, Director of CREATE, Dr. Ross Maciejewski, Director of CAOE, and Dr. Fred Roberts, Director of CCICADA to organize the *Workshop on the Supply of Labor During the Pandemic*. The workshop was held on August 21, 2020 and organized around two panels—a panel on *Workplace Safety* was followed by one on *Workforce Issues and Economic Costs*.

3.1. Panel on Workplace Safety

Panelists:

- John Dony, National Safety Council
- Captain Andrew E. Tucci, U.S. Coast Guard (retired)
- Dr. Gina Ligon, Professor of Management and the Jack and Stephanie Koraleski Chair of Collaboration Science in the College of Business Administration at the University of Nebraska at Omaha, as well as Director of the National Counterterrorism, Innovation, Technology, and Education (NCITE) COE
- Dr. William Spriggs, Professor of Economics, Howard University and Chief Economist to the AFL-CIO
- Bill Richmond, Chief Operating Officer, National Security Directorate, Pacific Northwest National Laboratory

The Panel on Workplace Safety was moderated by Fred Roberts.

"For Blacks and Latinos [COVID] is about work. … If we go occupation by occupation where we know people are exposed, this is overwhelmingly Black and Hispanic workers." Bill Spriggs, Howard University and Chief Economist,AFl-CIO.

The marine transportation system is critical to the world's economy and a critical component in the world's food supply. It is very broad, and so is its workforce, which includes vessel operators, port operators, longshoreman, truck and rail operators, lock and dam operators, those working on intra-modal connections, etc.

CAPT Andrew Tucci described some of the special issues facing the marine transportation system:

- Vessels are closed environments that are prone to COVID transmission.
- The industry is, by definition, mobile and global, with concomitant COVID risks.
- Merchant mariners (vessels masters and crews) often have pre-existing health factors that add to COVID risks.
- Ports are chokepoints, so putting vessels and/or workers in quarantine can lead to congestion and delays in supply chain activity across the economy.

- The Jones Act limits the ability of vessel operators to hire non-U.S. personnel.
- Many jobs in the marine transportation system require high skills and years of experience, making it difficult to meet the needs of a surge during a disaster.
- Collisions, oil spills, and other maritime disasters require many personnel coming from different areas, and working closely in conditions in which hygiene is challenging, even in the absence of COVID concerns.

CAPT Tucci also pointed out that there may be some positive outcomes from the pandemic. First, it may accelerate automation, which is lagging in the marine industry compared to other sectors. Second, working remotely may heighten awareness of the need for cyber security.

Bill Richmond talked about how PNNL closed down and then partly reopened. He shared some important lessons learned from the closure of a major research lab:

- There are wide exceptions to required lockdown for workers in national security, but essentially none for basic science.
- Technical infrastructure enabled successful telework.
- "Over-communication" with the workforce was important; detailed, direct instructions to staff are important—don't expect them to make decisions alone.
- Close contact with state and local health departments leading to internal testing and contact tracing was important.
- It was important to reverse the cultural bias against staying home when you don't feel well.
- Daily checklists for employees reminded them of the importance of maintaining appropriate health behaviors.

The rapid and wide-scale adoption of telework is leading us to re-examine the future of remote work:

- How do we optimize collaboration without physical presence?
- We are recognizing that work is a thing you do, not a place you go.

Gina Ligon, Director of the NCITE COE. said that COVID-19 accelerated changing trends in counter-terrorism work, trends already underway before the pandemic. She noted that a large percentage of counter-terrorism workers are teleworking. These workers may not be using DHS computers, and they are certainly not in a classified environment. This environment has accelerated cooperation across the intelligence community, and there may be opportunities for new organizational structures.

William Spriggs provided data from a CDC study in Georgia about the prevalence of COVID-19 infections in Blacks and Latinos that challenged some widely-reported "facts":

- The prevalence of diabetes, cardiovascular disease, chronic lung disease, and severe obesity among Black and non-Black COVID-19 patients was not significantly different; only hypertension was more common in Blacks.
- The frequency of invasive mechanical ventilation and of fatality did not differ by race.
- COVID is more prevalent in the Black community, but Blacks are not more likely to die if they catch COVID.

For Blacks and Latinos, COVID is a work-related problem (Figure 1):

- COVID incidence is much greater among working age Black and Latino populations than among whites.
- Black and Latino workers are over-represented in those professions at great risk because they interact with the public or work in close proximity to other workers.
- Because they are low wage workers, they feel greater pressure to work, even if they are not well.
- Fewer than one in five Black workers and roughly one in six Latinos are able to work from home.
- And, especially for Latino workers, the rise in unemployment has demonstrated the fact that they lack the safety net of access to health insurance.

In closing, Spriggs noted that we need to do a better job of understanding exposure by industry, shedding light on another commodity in short supply—data. Spriggs said, "*The CDC simply does not have enough data by occupation when it is reporting cases*."

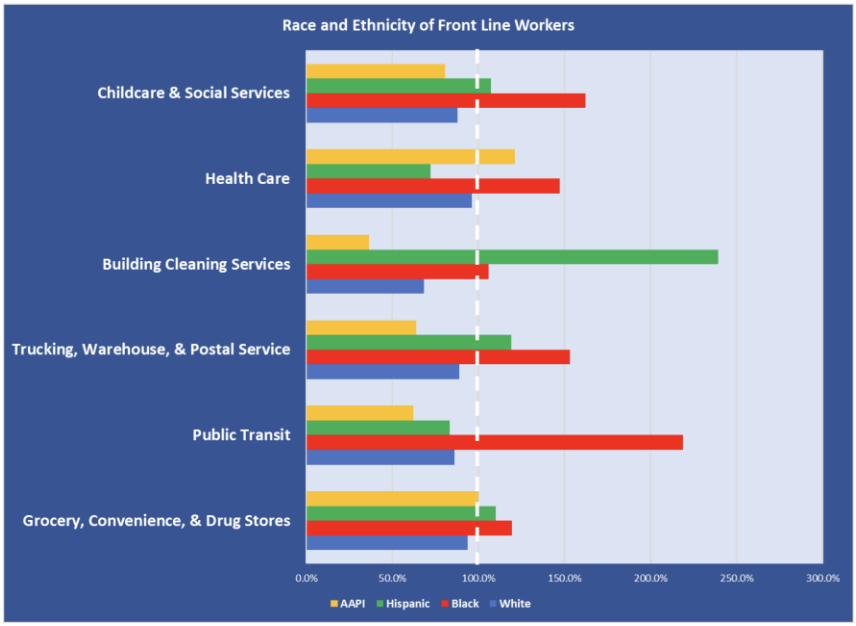


Figure 1: Blacks and Latinos are over-represented in front-line jobs where they interact with the public or work in close proximity to other workers.

Source: Rho, Brown and Fremsted, A Basic Demographic Profile of Workers in Frontline Industries, Center for Economic Policy and Research, https://cepr.net/a-basic-demographic-profile-of-workers-in-frontline- industries/

Chart credit: William Spriggs

Whether or not a worker feels safe going to work during or after a disaster depends on changes made in the workplace, communication about those changes, and the risks involved. John Dony of the National Safety Council (NSC) described resources the NSC has made available to assist businesses of all kinds in making the workplace safer. Dony emphasized the importance of communication to ease the process of returning to work. He noted that a communication plan should:

- Involve effective, timely, and frequent communication to create a shared sense of safety and security among the workforce;
- Include details of the transition;
- Anticipate employee concerns and questions;
- Exhibit enhanced caring from leadership; and
- Help employees practice better awareness of their surroundings for physical distancing and more.

3.2. Panel on Workforce Issues and Economic Costs

Panelists:

- Tony Cheesebrough, Chief Economist, Cybersecurity and Infrastructure Security Agency (CISA), DHS
- Dr. Janet Kohlhase, Professor of Economics, University of Houston
- Dr. Richard John, Professor of Psychology and Associate Director CREATE, University of Southern California
- Dr. Aaron Strong, Economist, RAND Corporation

The Panel on Workforce Issues and Economic Costs was moderated by Adam Rose.

Richard John of CREATE revisited the topic of communication. He discussed communication in terms of gain-loss framing effects in risk messaging. Based on experiments he conducted, he found differing risk averse behavior emerged with different kinds of disasters, with more risk averse behavior during hurricanes and floods, and less during earthquakes. Professor John also noted that risk perception, emotions, cognition, and behavior change as a disaster unfolds. Studies of a simulated evolving biological disaster (flu epidemic) showed that emotional, cognitive, and behavioral responses to the evolving disaster increased as the disaster escalated. However, avoidance behavior was more pronounced when the origin of the flu was unknown as opposed to when it was known to have been caused by a terrorist attack or a medical lab accident. This has implications for message framing during an evolving disaster such as a pandemic. Message studies show that building trust is key.

Healthcare and Education are two occupations that have been at the center of the pandemic. Different occupations have different risks as well as different economic "multiplier effects." Both Adam Rose and Aaron Strong discussed the influence of occupation on economic impacts. Strong's occupational analysis of 800 different occupations combined both economic and epidemiological considerations. Among the conclusions from Strong's analysis:

- Healthcare, retail, and education are in the higher risk, higher economic impact category.
- Real estate is in the higher risk, lower impact category.
- Chemical manufacturing is in the lower risk, lower impact category.
- What we are looking for are lower risk, higher impact industries, but these are hard to find.

During the pandemic, many people worked at home. In the short run, Janet Kohlhase observed, this had a number of positive impacts, including reduced roadway congestion and improved air quality. However, in the long run, if increased teleworking reduces face-to-face contact at the workplace and threatens the viability of employment subcenters in urban areas, creativity may suffer. Could the potential loss of creativity and reduced viability of employment subcenters have a severe impact on those urban areas and a ripple effect on the entire economy? Moreover, if firms follow the last-hired, first-fired paradigm, could that impact the improved diversity in the economy and also have negative economic growth consequences?

COVID-19 caused one of the most dramatic impacts on the U.S. economy in our history. Several speakers discussed different modeling approaches to estimate how dramatic the effect had been and to predict future impact. Tony Cheesebrough described a 2020 CISA study with the CAOE COE carried out by Victoria University's Centre of Policy Studies (CoPS). The results included the following findings and projections:

- COVID-19 will reduce U.S. GDP over the next year by 12.3% ($2.6 trillion) and employment by 12.7% (22.8 million one-year jobs).
- Tourism industries are the most impacted, with hotels and restaurants greatly affected.
- Construction will be slow to recover, with output 24% below baseline even after two years.
- Many national critical functions are impacted, in particular the education industry and air transportation of passengers and cargo.

The study planned to begin producing monthly updates in October 2020. These updates would be calibrated by the most recent employment and GDP statistical releases.

Adam Rose described computable general equilibrium models that characterize the entire economy as a set of interrelated supply chains and that are based on decisions by individual producers and consumers in response to price signals, regulations, and external shocks within limits of available capital, labor, and natural resources. His analysis performed in conjunction with colleagues at CREATE led to the conclusions that:

- Mandating closures generated a 37.5% drop in the U.S. GDP, even while telecommuting muted the negative impact.
- Teleworking is easier for some sectors (computer sector, academics) but harder in others (hospitals, retail, hair salons). The information sector, financial sector, and professional services had telecommuting before the pandemic.
- Pent-up demand could reduce the overall negative economic impact on GDP by 17.8%.

4. Workshop on the Food Supply Chain During the Pandemic

The COVID-19 pandemic created significant increases in food insecurity across the U.S. at a time when the ***farm-to-fork*** food supply chain was stressed in many areas. Federal, state, and private efforts helped mitigate some of the most urgent needs, but food insecurity remains a significant health and national security issue.

U.S. food supply chains are generally resilient. However, some aspects are vulnerable to disruptions in inputs, labor availability, transportation, and the cascading impacts of misinformation, malicious efforts to compromise the perceived integrity of our food supply chains, or use of disruptions to leverage market gains in global markets.

These issues led Dr. Greg Pompelli, Director of CBTS, Dr. Ross Maciejewski, Director of CAOE, and Dr. Fred Roberts, Director of CCICADA to organize the *Workshop on the Food Supply Chain During the Pandemic*. The workshop was held virtually on August 27, 2020 and organized around two panels—a *Panel on Hunger Relief* was followed by a *Panel on Food Supply Chain Vulnerabilities*.

4.1. Panel on Hunger Relief

Panelists:

- Blake Thompson, Chief Supply Chain Officer, Feeding America

- Katie Nye, Baylor Collaborative on Hunger and Poverty, Baylor University
- Kevin King, Deputy Commissioner of Agriculture, New York State Department of Agriculture and Markets

The panel was moderated by Dr. Lauren Davis, Professor of Industrial and Systems Engineering at North Carolina A&T University.

"This was the perfect storm for our organization and our supply chain. Not only was the demand a record unprecedented demand. … We had a 70% decrease in volunteers." Blake Thompson, Feeding America

The Hunger Relief panel reflected on lessons learned in first six months of the pandemic and identified significant issues that need to be examined for the current pandemic and in preparation for future disruptions.

The immediate impact of the pandemic on food insecurity in the U.S. was dramatic. Blake Thompson of Feeding America provided some figures on the magnitude of the crisis:

- Feeding America saw a decrease of 70% in its volunteers.
- At the same time, it saw a 46% increase in number of Americans who were food insecure, rising from an estimated 37 million people to an estimated 54 million people. And, from an estimated 1/9 Americans at risk to be food insecure to 1/6.
- An estimated 18 million children were food insecure. This rose from an estimated 1/7 American children at risk to be food insecure to 1/4.

The estimated demand for charitable food through June 2021 rose to 17 billion pounds—outstripping all current government programs for relief of food insecurity. Feeding America estimated that they would be able to fill 7 billion pounds of this gap with their acquired food supplies (which include public and private sector accessible food supplies).

Feeding America estimated that the pandemic led to a 46% increase in food insecurity. Image credit: Feeding America with permission of Blake Thompson.

In addition to dealing with unprecedented demand and fewer volunteers, Thompson noted that food distribution charities faced other challenges, including:

- The need for new procedures to distribute food with social distancing measures; and
- The large increase in perishable food among the food supplies available for distribution and the associated need to maintain freshness.

Katie Nye, Statewide Field Director for the Texas Hunger Initiative, described others:

- Difficulty in finding shelf-stable food items;
- Competition with other distributors and purchasers;
- Dramatic increases in online purchasing leading to delays in delivery; and
- Difficulty in locating people in remote rural areas where delivery addresses are not in forms that are typically encountered. For instance, in some Native American communities, addresses may be defined by latitude and longitude.

Kevin King, Deputy Commissioner at the New York State Department of Agriculture and Markets, described the situation in New York State in April 2020:

- Federal and local aid packages were significant but not connecting with local producers.
    - The second and third coronavirus stimulus packages included over $48 million in administrative and commodity funding for NY food banks.
    - NYC committed $25 million for metropolitan-based emergency food providers.
- There were lots of financial resources to support feeding, yet food supplies were not getting to people. There was:
    - Milk dumping at dairy farms;
    - Produce from last year's harvest still in cold storage with nowhere to go;
    - Idling of the Long Island fishing fleet; and
    - Farms and food producers left without markets.

The panelists said that there would be more than enough food to feed the 54 million Americans who are food insecure if the challenges could be overcome. Kevin King described the Nourish New York Initiative through the NY State Department of Health (DOH) aimed at overcoming such challenges:

- Emergency funds to 10 foodbanks with suballocations to another 37 emergency feeding organizations;
- Administered by NYS DOH emergency contracts to foodbanks;
- Funds required to be spent on NY state products through:
    - Direct purchase
    - Food drive-through event with a local producer
    - Voucher program for dairy products.

These measures enabled NY state to end the dumping of dairy products by May.

The panelists all noted that most of the solutions were low tech:

- Use of cars and trucks to make deliveries;
- Use of Amazon and Uber to deliver to seniors at home;
- Pick-up lockers at grocery stores;
- Shipping food to schools for redistribution in areas where addresses are difficult to locate;
- Building on pre-existing relationships.

4.2. Panel on Food Supply Chain Vulnerabilities

Panelists:

- Dr. Michelle M. Colby**,** DVM, Chief, National Security Division, Office of Homeland Security, USDA
- Dr. LeeAnne Jackson, Center for Food Safety and Applied Nutrition, Food and Drug Administration
- Jeremy Jackson, Anneal Initiative, Inc.
- Col. John Hoffman, Senior Research Fellow, Food Protection & Defense Institute (COE), University of Minnesota

- Dr. Will Martin, Senior Research Fellow, International Food Policy Research Institute (IFPRI)

The panel was moderated by Dr. Dan Sumner, the Frank H. Buck, Jr. Distinguished Professor of Agricultural and Resource Economics at the University of California, Davis.

The panel identified critical vulnerabilities in our food supply chains that warrant greater attention, highlighting those vulnerabilities that may have broader social and national security impacts.

Will Martin of the International Food Policy Research Institute described the effect of the pandemic on the four pillars of food security:

- Availability
  - Production disruption occurred in some labor-intensive industries (though not so much in field crops, where there is natural social distancing).
  - Movement of workers was disrupted.
  - Demand patterns changed with the closing of restaurants and consumer reluctance.
- Access
  - The economic downturn resulting from COVID led to a sharp decline in household income worldwide.
  - This was especially serious in developing countries.
- Utilization
  - Health problems have reduced the ability to utilize food.
  - A reduction in dietary diversity has made people more vulnerable to illnesses.
- Stability
  - Even when food supplies are adequate, instabilities arise from trade policies and export bans and quotas.
  - It is important to keep food supplies moving through things like green lanes during a lockdown.

He argued that COVID-19 highlighted the need for regular assessments of vulnerability to food insecurity and that well-functioning borders are important for maintaining a diversity of food supply and minimizing food price shocks.

There are 16 critical infrastructure sectors whose assets, systems, and networks—whether physical or virtual—are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof. Presidential Policy Directive 21 (PPD-21): Critical Infrastructure Security and Resilience advances a national policy to strengthen and maintain secure, functioning, and resilient critical infrastructure. Food and Agriculture is one of those sectors. Yet, as Michelle Colby, Chief of the National Security Division in USDA's Office of Homeland Security, and LeeAnne Jackson of the FDA's Center for Food Safety and Applied Nutrition pointed out, this sector is intertwined with many of the others.

- The Critical Manufacturing Sector includes manufacturing of farm equipment; food processing equipment; packaging (e.g. cans and paperboard); and modes of transportation (e.g. trucks, trains, vessels that carry food).
- The Financial Services Sector is involved with processing of payments for food.
- The Energy Sector is involved with electricity and gas used in producing food.

- The Chemical Sector deals with the cleaning and disinfectants, plastics, and ethanol - CO_2 production relevant to food and agriculture.
- The Healthcare and Public Health Sector deals with community mitigation approaches for workforce health.
- The Transportation Systems Sector deals with aviation, highway and motor carrier, maritime transportation, pipeline systems, freight rail—all relevant to food and agriculture.

Colby and Jackson said that the Government Coordinating Council, co-chaired by USDA and HHS/FDA, collaborates with the Sector Coordinating Council (a self-organized, self-run, and self-governed body representing the food and agriculture industry) to aid in cross-sector collaborations to seek rapid solutions to urgent issues, such as how to prioritize PPE, cloth face coverings, disinfectants, and sanitation supplies.

Nation-states and non-state actors (e.g., terrorist groups) can exacerbate the effect of a natural disaster, either during the disaster or through advance planning that makes supply chains vulnerable. This was the observation of Jeremy Jackson, founder of Anneal Initiative, Inc., an analysis and strategic planning business.

For example, China is currently exerting dangerous levels of control over critical supply chains. China's dominance of rare earth metal production, for instance, may foretell significant future impact on other supply chains critical to food and agriculture, such as the fertilizer markets. Jackson urged workshop attendees to consider human threats to supply chain resilience along with natural outbreaks, to:

- Understand adversaries' philosophies, goals, strategies, and procedures.
- Look for case studies that can demonstrate approach and processes.
- Perform predictive analysis that identifies supply chain threats earlier.

COVID-19 demonstrated a variety of vulnerabilities in the food supply infrastructure, many of which are of broader concern than just during a pandemic. John Hoffman of the FPDI COE noted some of these vulnerabilities. According to Hoffman, employee health was identified as a critical issue for the Food Infrastructure during the 2004-5 Pandemic Planning. COVID-19 validated this issue. We have seen that:

- Work environments often require high density of skilled workers working in close proximity;
- The labor base in food production often has high percentage of immigrants as this is frequently an American work force entry job for immigrants; and
- Workforce public health training and implementation has language, cultural, family/social challenges.

Cyber-based systems are ubiquitous in the food sector. Hoffman pointed out that the cost of cyber attacks is unknown because few firms will share actual cyberattack impacts; yet, the available data show that the food sector is in the top 3-4 targeted sectors each year. Cyber threats to the food sector have grown during the pandemic, with targets including processors, transportation, and distribution. The sophistication of attackers and the poor state of cyber defense in the food industry creates a significant strategic risk to the U.S.

Hoffman also talked about all the ways in which food packaging became an issue during the pandemic:

- COVID-19's impact on the global system demonstrated the problems associated with the availability and agility of packaging suppliers to include our dependence upon foreign suppliers.
- The need to surge retail food production and curtail food service supply systems resulted in packaging supply shortages as suppliers had difficulty responding.
- These issues were exacerbated by disruptions in maritime transportation systems, closing of ports, and labor shortages in port facilities.
- Shortages in aluminum packaging as materials and production was diverted to other critical products further aggravated the shortages.
- Limited production capacity for HDPE plastic pellets impacted the shifts in production from food service channels to food retail

Prior to COVID-19, food packaging was not seen as a critical strategic resource.

5. Workshop on Supply Chain for Medicines, Vaccines, PPEs During the Pandemic

The rapid spike in COVID-19 cases in March and April of 2020 highlighted nationwide shortages of ventilators, test kits, masks, and other PPE, provoking competition between state and federal agencies and forcing us to rely on foreign sources for critical supplies. Vulnerabilities in critical supply chains became apparent.

A pandemic raises major questions for the nation's stockpile of critical medicines. How big should such stockpiles be? How do you keep items fresh? What are the priorities for distribution? Who gets items first and how is the decision made?

From early in the pandemic, there was a rush to produce vaccines, but polls showed that many people would be reluctant to take a vaccine. What are the reasons for such reluctance? Vaccines present also present special supply chain challenges, such as the need for refrigeration. Different vaccines will present different challenges and have different efficacies. How should these differences be managed? Who should get which vaccine first? How will they be distributed?

Disasters inevitably bring out new kinds of crimes. What are the challenges we face with illegal or low quality PPEs, counterfeit medicines or vaccines, and other related crimes?

These issues led CCICADA Director Fred Roberts and other Rutgers faculty members—Alok Baveja, Tamra Carpenter, Weiwei Chen, Dennis Egan, Benjamin Melamed, and Viswanath Narayan—to organize the *Workshop on Medicines, Vaccines, and PPEs during COVID-19*. The workshop was held virtually on August 27, 2020 and organized around two panels—a *Panel on Vaccines* was followed by a *Panel on Medicines and PPEs*.

5.1. Panel on Vaccines

Panelists:

- Joe Lewis, Managing Director, Deloitte Consulting
- Karin Shanahan, SVP of Global Biologics & Sterile Operations, Merck
- Bill McLaury, Rutgers School of Business (retired from Novartis)

- Dr. Juergen Richt, Director, CEEZAD COE

The Panel on Vaccines was moderated by Fred Roberts.

As Juergen Richt, director of the CEEZAD COE, pointed out, there were already some 135 vaccines in the pipeline at the time of the workshop. This meant that there were also 135 supply chains being established. Of the vaccines in development, there were 21 in phase 1, 13 in phase 2, 8 in phase 3, and two approved for use (in Russia and in China for military use). Karin Shanahan of Merck said that the typical life cycle for developing a vaccine is four to ten years to test, develop a pipeline, and administer it to a lot fewer people than we will need to vaccinate for COVID-19. Richt, Shanahan, and William McLaury, a former supply chain executive at Novartis Pharmaceuticals, raised many questions:

- The landscape of COVID-19 changes rapidly. How will future changes affect the efficacy of vaccines?
- How will we be able to produce orders of magnitude more vaccine doses than the industry has ever produced for the flu vaccine, and in a shorter amount of time?
- Will there be a single dose or two? Some vaccine manufacturers have already indicated that two shots will be required for vaccine efficacy.
- The global industry-manufacturing capacity currently is 5 billion doses per year, and ~5.6 billion vaccinated individuals will be needed to achieve "herd immunity." If two doses are needed, we will need ~11 billion doses. Because 11 billion doses or even 5.6 billion doses won't all be available right away, how will countries decide who gets it first?
- How do we overcome the manufacturing conflict with flu vaccines and other vaccine products using the same materials and manufacturing capacity? Can we have a flu + COVID combination vaccine?
- Will the vaccine be mandatory (at least in some countries)?
- Will people retain their immunity over the long term, or will we need shots each year?
- What is the immune response in older, pregnant, or immuno-suppressed people?
- Do we need a fully protective vaccine or is partial protection sufficient?
- Most vaccines typically require refrigeration during transportation and storage (cold chain). The industry doesn't have enough cold chain capacity to transport many millions of doses in such a short time frame. Can UPS and other companies build up their cold chain capacity fast enough?
- How will it be distributed globally, especially in areas where there are extreme temperatures?
- How can manufacturing capability and key supplies be arranged well in advance?
- Will we be able to find enough skilled personnel capable of working in the sterile environment with temperature controls needed to manufacture the vaccines?
- No one entity owns the entire vaccine supply chain. How do we achieve the required collaboration and coordination to accomplish manufacturing of enough vaccine?
- The vaccine may be delivered through multiple distribution channels (e.g., hospitals, clinics, doctor's offices, pharmacies, government agencies such as the CDC, nursing homes, workplaces, prisons, military bases, schools, etc.). How will we work out the complex logistics of delivery?

- We need pre-clinical animal testing of vaccines and therapeutics and very few facilities can perform these tests. Will we be able to develop a national effort to support the existing facilities and develop more of them, at least for future epidemics?
- How will people respond to the anti-vaxers' messages?
- We already see fraud in counterfeit drugs, low-quality PPEs, and vials. Will we see counterfeit vaccines? A black market for vaccines? And, how can we protect against these things?

In the intervening time between the workshop and the conclusion of this project, many of these questions have been addressed, and several were considered in the final two workshops held by this project.

In the early days of COVID, we saw shortages, hoarding, panic buying, and other reactionary behaviors. According to Joe Lewis of Deloitte Consulting this was largely driven by a lack of transparency and trust. When there is a lack of trust in equitable distribution, it creates an "everyone for themselves" mentality.

Lewis said that supplies were mostly adequate, but needs differed because the virus hit different places at different times. In such a situation, one can handle increased demand by collaborating and moving required material to areas of increased demand. This depends on the use of tools like real-time demand sensing to shape transparency and trust. Rory Yanchek of 3M also commented that getting real-time data about COVID and requirements for PPE was a challenge during the early peak of the crisis. A uniform data collection strategy and ownership needs to be in place. Trust in the data is key for future success in handling a pandemic.

Lewis said that the use of blockchain increases transparency and expedites market accessibility for critical products through sharing trusted data sources among manufacturers, vendors, and regulators. The use of a control tower tool can provide visibility to inventory across the end-to-end supply chain**,** enable alerts, generate prescriptive insights, and trigger self-driving execution, with the capability of acquiring data from multiple stakeholders and gaining insights from advanced analytics.

Applying these ideas to a new COVID-19 vaccine, Lewis observed that at the beginning, there would be insufficient supply to meet the demand, so transparency around how allocation decisions are made and trust in equitable distribution would be key. During a second phase when supply could meet demand, collaboration and coordination would be critical factors in optimizing distribution. It would not be until a third phase that more traditional competitive markets such as with flu vaccine become the norm.

William McLaury pointed out that there can be related, but not necessarily obvious, supply chain issues that could hold up availability of vaccines:

- Potential shortages of medical glass vials and stoppers. These are sourced primarily from suppliers in China. Shortages date back to before the pandemic. There could be shortage of the sand used to make glass vials. Stoppers are a potential issue as well. They are heavily regulated as the rubber or latex components can't interact with the product inside the vial.
- A related issue is that a few manufacturers dominate the stopper business, and some of them also make the vials.

- Potential short-term shortage of syringes. Becton Dickinson reported that there is not enough capacity in the industry to produce billions of syringes and needles in a significantly compressed time frame.
- Foreign sources of raw materials and chemical ingredients are needed to produce the vaccine. Some adjuvants and plasmids are in short supply.
- There will likely be global competition for some materials, and the country where that material is produced will have the ability to control capacity and distribution. We saw this happen with some drugs, PPEs, and other healthcare items.

Months after this workshop, the availability of dry ice for cold storage of vaccines emerged as one of these types of issues.

5.2. Panel on Medicines and PPE

Panelists:

- Eric Garvin, Head of Pharma Solutions, Chronicled
- Dr. Daniel Gerstein, RAND Corporation, Homeland Security Operational Analysis Center
- Viswanath Narayan, Rutgers School of Business (retired from Pfizer)
- Brian Weinhaus, Operation Stolen Promise, Homeland Security Investigations, ICE
- Rory Yanchek, Vice President and General Manager, Government Markets, 3M

The Panel on Medicines and PPEs was moderated by Dr. Dennis Egan, Assistant Director of CCICADA.

Daniel Gerstein of the RAND Corporation noted that people are calling for changes to restore manufacturing of critical items, decouple global supply chains, and become more self-sufficient. Gerstein wondered whether this is possible and, if so, who would pay the increased cost.

"We need to treat public health preparedness—including our supply chains—as a national security issue." Daniel Gerstein, RAND Corporation

Our "just in time" delivery systems have been designed to optimize costs through prediction and minimizing inventories, but they lack resiliency in times of crisis. The result during COVID-19, according to Dr. Gerstein, is that 95% of companies will be impacted by COVID-19 and only 56% had a plan to address supply disruption from China, a source of many of the key active pharmaceutical ingredients. Trade wars and excessive competition do not work in a global economy or in a time of crisis, Gerstein said. We cannot have one system for daily use and another for times of crisis.

Gerstein added that we need to treat public health preparedness, including supply chains, as a national security issue and develop a strategic national supply chain approach. The Strategic National Stockpile (SNS) needs to be viewed as part of a broader national supply chain that combines stockpiling, direct contracting with manufacturers, warm production lines for some key commodities, procuring of large quantities at the national level to take advantage of economies of scale, and shortening supply chains. Gerstein called for the development of methodologies to:

- Improve current supply chain visibility
- Determine appropriate balance between efficiency and resilience
- Develop principles, strategies, policies, and regulations for supply chains

- Establish and validate the algorithms that will guide the supply chains
- Model new risks and costs (network flow models or time series forecasting)
- Improve situational awareness through use of advanced capabilities
    - Technology: Internet of Things, artificial intelligence, robotics, and 5G
    - Handling unforeseen challenges: COVID-19, trade war, act of war or terrorism, regulatory change, labor dispute, sudden spikes in supply or demand, natural disaster, or supplier bankruptcy

At a National Academies workshop on Global Health Risk Framework: Research and Development of Medical Products, Tadataka Yamada said that: "Manufacturing of products for emergency responses can be complex because the products are often for problems that have not yet occurred." Panelist Viswanath Narayan used this quote to explore issues involved in preparing products for the "next" pandemic. He pointed out that we have reduced capacity to meet cost goals and have not accounted for emergency growth in volume. Identifying and classifying product class early to define a service level is key to meet future surge in demand during a pandemic. Classifying products, for example, as medically necessary or medically essential will set the supply chain strategy to identify similar platforms to absorb shortages during a pandemic. This is akin to disaster recovery services in IT with a cold backup site for essential computer operation to run the business. Another problem is a proliferation of different SKUs for the same product aimed at different prospective purchasers. However, there are no capacity allocation distinctions for different SKUs. Planning for the next major event will require a more specific strategy, and we need to plan this before the next pandemic.

Narayan also posed some research challenges:

- Can a switch from batch to continuous manufacturing approaches benefit both routine and emergency production?
- Is stockpiling bulk or intermediate manufacturing components for finishing when needed (e.g., bulk vaccine stocks), potentially saving space and extending expiration, a viable strategy?
- Can a data-driven allocation model be developed to allocate and provide equitable distribution of drugs and PPEs?
- Can demand forecasting during a pandemic be developed with a certain confidence interval to meet supply and demand challenges?
- Can robust replenishment policies with stockpiling to keep the products fresh, using a continuous consumption mode for different classes of products, be developed and agreed upon?

Rory Yanchek of 3M described ways in which companies can collaborate with each other without government involvement to develop a range of innovative solutions to protect healthcare workers and first responders and to ramp up the production of important products that are needed. 3M created an office to accelerate such collaboration. He gave the example of collaboration between 3M and Ford on a powered-air purifying respirator, where 3M had the capacity and approvals and Ford had the fans.

Yanchek said that their External Collaboration Response Team has reviewed over 500 external collaboration requests from all types of markets and businesses, getting on average 30 to 40 new

requests per day. Major areas of focus/collaboration are: PPE capacity increase, disinfection of PPE automation, and non-3M product support. Yanchek said that the impact of these actions will continue beyond current efforts and involve connecting in new and impactful ways with other company partners.

Brian Weinhaus of the ICE-HSI led National Intellectual Property Rights Coordination Center described some of the health-related frauds they are finding in Operation Stolen Promise.

- Unapproved and/or counterfeit pharmaceutical or supplement products
    - Medications
    - Fake "immunity" pills
    - Drugs marketed as cures for COVID-19
    - Fake vaccines
    - Virus shutout packs/lanyards
- Counterfeit or unapproved PPEs and life safety products:
    - N95 respirator masks
    - Protective gowns
    - Protective gloves
    - Protective eyewear
    - Full face shields
    - Sanitizing products
    - Hygiene products
    - Medical and laboratory equipment
- Hoarding and price gouging
- Scams of all kinds such as donations to nonexistent charities
- Increased cyber attacks
- Increased financial fraud

Operation Stolen Promise was created to counter such crime. It partners with the private sector and with domestic and foreign partner agencies.

Karin Shanahan noted that every company has a robust fraud detection program, using advance surveillance techniques to identify fraud early. Rory Yanchek pointed out the importance of collaboration between government and the private sector in protecting against fraud and price gouging. He said that 3M, for example, has created a hotline for fraud, price gouging, and counterfeits, and is collaborating with national and local legal authorities to bring lawsuits in multiple states and Canada.

MediLedger, an effort designed to defend against counterfeit drugs, originated as a joint effort of leaders from 25 companies in the pharmaceutical industry—manufacturers such as Pfizer and Novartis, wholesalers such as McKesson and Cardinal Health, and dispensers such as Walmart and Walgreens. Panelist Eric Garvin leads the MediLedger Project. Garvin told us that the project aims at tracing transactions, e.g., from manufacturer to wholesaler to dispenser and backwards with returns. By being able to track all of the transactions, one can hopefully defend against pharmaceutical fraud. MediLedger defines a real-time industry-wide network to automate the way trading partners do business together.

MediLedger is an attempt to use serialized data exchanges for prescription drugs using a blockchain/ledger-based system. Blockchain allows each player to maintain the privacy of their data while sharing information in a secure way. Proof of every update/transaction is published to blockchain. The pilot of MediLedger showed that business rules for each transaction can be enforced by blockchain smart contracts in real time while keeping each company's data 100% private. However, Garvin said, long-term success will require strong participation and adoption from all segments of the supply chain (manufacturers, wholesalers, dispensers, and service providers).

6. Workshop on COVID-19 Vaccines: Efficacy & Safety

A year into the COVID-19 pandemic, with vaccine distribution ramping up across the US and other parts of the world, attendees of the *Workshop on COVID-19 Vaccines: Efficacy & Safety* received a hopeful message from keynote speaker Florian Krammer, Professor of Vaccinology at the Icahn School of Medicine at Mount Sinai:

"***SARS-CoV-2 is not a hard virus to immunize against***."

Professor Krammer's hopeful message was echoed by a panel of experts in vaccine development and immunology, including Dr. Philip Dormitzer, who leads **Pfizer**'s viral vaccines research and development programs, and Dr. Randy Hyer, Senior Vice President of Global Medical Affairs at **Moderna**.

The workshop was held on January 7, 2021 and organized by Dr. Juergen Richt, Director of CEEZAD, and Dr. Fred Roberts, Director of CCICADA. The workshop discussed the COVID-19 vaccines under development, how well they work, what types of protection they provide, how they might contribute to a global strategy to combat the pandemic, and what questions remain unanswered. The two-hour event kicked off with Krammer's keynote providing an overview of COVID-19 vaccine development. This was followed by presentations by a panel of experts describing specific aspects of vaccine safety and efficacy.

Keynote:

- Dr. Florian Krammer, Professor of Vaccinology, Icahn School of Medicine at Mount Sinai

Panelists:

- Dr. Philip Dormitzer, Vice President and Chief Scientific Officer Viral Vaccines, Pfizer
- Dr. Hana Golding, Chief of the Laboratory of Retrovirus at the Division of Viral Products, Center for Biologics Evaluation and Research (CBER), FDA
- Dr. Randy Hyer, SVP, Global Medical Affairs, Moderna
- Dr. Fred Cassels, Global Head, Enteric and Diarrheal Diseases, PATH
- Dr. Adolfo Garcia-Sastre, Professor, Departments of Microbiology and Medicine and in the Tisch Cancer Center, Icahn School of Medicine at Mount Sinai
- Dr. Karen Makar, Senior Program Officer, Bill & Melinda Gates Foundation
- Dr. Stanley Perlman, Professor of Microbiology and Immunology, and of Pediatrics, University of Iowa

6.1. It's All About the Viral Spikes

Coronaviruses are a family of viruses that affect humans and other animals. In humans, they usually cause relatively mild upper-respiratory, cold-like symptoms, and are thought to be zoonotic in origin. Recently, we have seen three coronaviruses make the jump from animals to humans causing severe respiratory diseases. These include the SARS outbreak in 2003, MERS in 2012, and now SARS-CoV-2 causing COVID-19.

SARS-CoV-2 consists of a lipid membrane with the viral spike, envelope and matrix proteins, and genomic RNA protected by the nucleocapsid protein on the inside; the viral spike protein on the surface of the virus forms the corona of the virus for which it is named (see Figure 2). The site on the virus that binds to the receptor on human cells is called the *receptor binding domain* (RBD), and it is part of the spike protein. When somebody gets infected with SARS-CoV-2, the body mounts an antibody response to viral proteins including the spike protein and the RBD, and these antibodies inhibit the binding of the virus to cells. There is growing evidence that the anti-RBD and anti-Spike antibodies correlate with protection from disease. In addition, the body also produces antiviral T-cells, which are a type of white blood cell that participates in immune response, and these T-cells also target viral proteins including the spike protein.

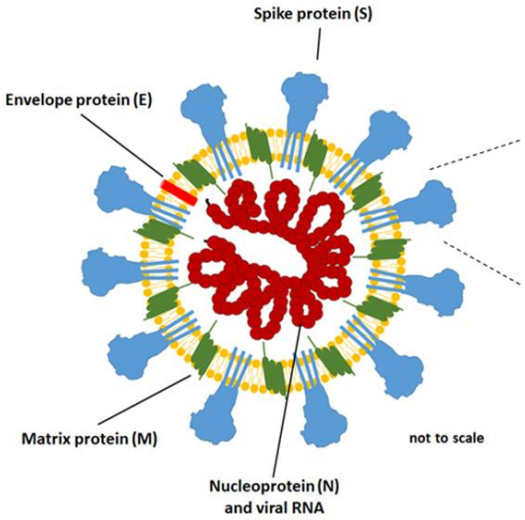


Figure 1: Key features of the SARS-CoV-2 virus. Excerpted from presentation by Florian Krammer.

Vaccines produce an immune response by imitating key aspects of natural infection. For SARS-CoV-2, it's all about the immune responses to the spike protein.

6.2. The Vaccine Development Pipeline Is Large

The discovery phase of the vaccine for COVID-19 has moved incredibly fast. Panelist Karen Makar noted, "*We have gone from a prototype pathogen to first in human in three months*."

The number of vaccine candidates is also extraordinary. The World Health Organization (WHO) lists 173 vaccine candidates in preclinical development and another 64 in clinical trials, seven of which are already licensed for use in some countries. These vaccine candidates are developed using a wide range of vaccine production technologies, or *platforms*. The spectrum of such platforms ranges from more traditional inactivated vaccines, to viral-vectored vaccines, to the newest mRNA vaccines produced by Pfizer and Moderna. In Krammer's words, "*This is the biggest experiment where we test different vaccine platforms, in humans, in parallel, against one pathogen.*"

The scale of this experiment promises a wealth of new insights for scientists. Some of the platforms represented in late stages of the clinical pipeline of SARS-CoV-2 vaccine development include:

- **Inactivated SARS-CoV-2.** The Sinovac vaccine CoronaVac licensed in China uses inactivated SARS-CoV-2 virus.

- **Viral-vectored vaccines that express the spike protein**. The most developed of these vaccines are based on adenoviruses that have been engineered to express the spike protein but has been disabled from replicating within the vaccine recipient. Vaccines of this type include the Russian Gamelya vaccine and the CanSino vaccine which is licensed for use by the Chinese military. Vaccines developed by Janssen and AstraZeneca using this technology are in Phase III trials.
- **Recombinant protein-based vaccines**. Recombinant protein vaccines include those based on the spike protein and those based specifically on the receptor binding domain of the spike protein. Included in this category is the Novavax vaccine, which is in Phase III trials.
- **Nucleic acid-based vaccines based on either DNA or RNA**. Both the Pfizer and Moderna vaccines licensed for emergency use in the US are mRNA vaccines.

In describing the clinical pipeline, Krammer says, "*There are so many candidates. It's actually unbelievable*."

6.3. The Vaccines Offer Impressive Levels of Protection

COVID-19 can cause both upper and lower respiratory tract infections. Upper respiratory infections are associated with congestion and cold-like symptoms in the nose and trachea, while lower respiratory infections are associated with more severe symptoms such as lung inflammation and pneumonia.

> *"We need to realize we have been extremely lucky in terms of vaccines with this pandemic. The next pandemic, we may not be so lucky."*
> *Dr. Adolfo García-Sastre, Icahn School of Medicine a Mount Sinai*

In pre-clinical trials on non-human primates, all of the leading vaccine candidates induced an immune response that protected the lung from virus replication; however, none of them fully protected the upper respiratory tract system. Panelist Adolfo García-Sastre noted that protecting the lower respiratory tract is a priority for any vaccine in order to avoid the most severe cases of the disease and to reduce fatalities. But, to break the transmission cycle of an airborne respiratory disease like COVID-19, preventing virus replication in the upper respiratory tract is important but lacking so far.

Clinical trials indicate that many of the leading vaccine candidates induce strong neutralizing antibody responses in humans. Among the vaccines that may ultimately be fully licensed for use in the US, those developed by BioNTech/Pfizer and Moderna are farthest along and have demonstrated impressive results in Phase III trials.

The Pfizer trial included over 43,000 individuals among whom 170 cases of COVID-19 were reported—162 in the placebo group and 8 in the similarly sized group who received the vaccine, yielding an efficacy of roughly 95%. The trial included a subgroup of individuals aged 65-85, and the vaccine efficacy in this higher-risk group remained high at about 94%.

Moderna's study included over 30,000 participants among whom 196 COVID-19 cases were recorded—185 in the placebo group and 11 in the group receiving the vaccine, yielding an efficacy of roughly 94%. Randy Hyer noted that Moderna worked hard to assure that the population in the Phase III trial was representative of the US as a whole, particularly with respect

to communities that have been hard hit by the pandemic. They considered factors such as age, existence of comorbidities, and ethnicity, and observed good vaccine efficacy in all groups, though slightly lower with advanced age or comorbidities. Comparing vaccine efficacy in non-Hispanic whites versus efficacy in communities of color indicated very high vaccine efficacy in both groups.

The number of severe COVID-19 cases was much lower in the vaccine group for both the Pfizer and Moderna vaccines. In the Pfizer trial, only one of the ten observed severe COVID-19 cases was in someone receiving the vaccine. In the Moderna trial, none of the 30 severe cases were in people receiving the vaccine.

A graph of cases occurring over time in the Pfizer Phase III trial indicates that protection from disease is already beginning 10-12 days after receiving the first vaccine dose (Figure 3). Results of the Moderna vaccine Phase III trial look very similar.

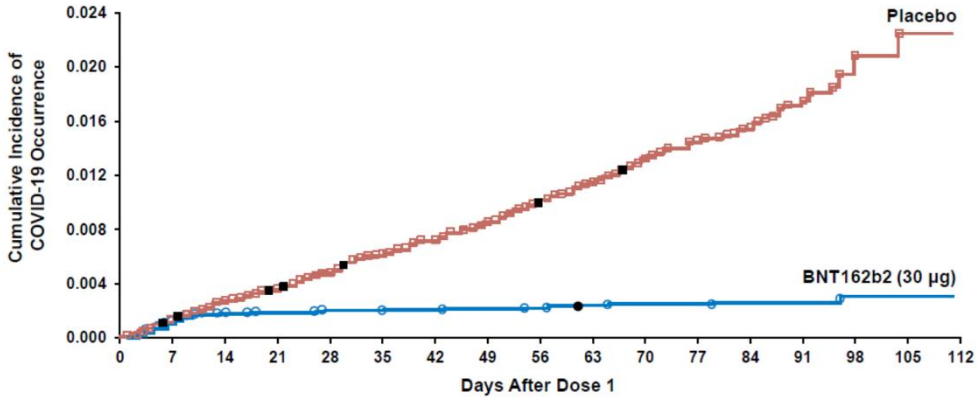


Figure 3: Cases over time for the vaccinated group (blue) and the placebo group (red) during the Pfizer trial. Included with permission of Philip Dormitzer.

Pfizer's Philip Dormitzer was both surprised and pleased that efficacy is achieved so quickly after the first vaccination. He said, "*Even at 21 days [after the first dose] there is very little neutralizing antibody detectable; yet, sometime between 10 and 12 days, you start to see efficacy, and it increases from there. Why do we have this early efficacy? Is it that the virus is very sensitive to neutralizing antibody and just a small amount is enough, or are there other mechanisms that are actually responsible for this early efficacy?*" He also noted that trial participants receive a second dose at 21 days after the first, so data on duration of protection beyond 21 days following just one dose do not exist.

6.4. Vaccine Safety & Licensing

Vaccines can trigger a range of side effects that are collectedly referred to as *reactogenicity*. These side effects are often part of the body's innate immune response to the vaccine or components within the vaccine formulation and can include injection site pain, headache, fatigue, muscle pain, elevated temperature, and mild flu-like symptoms. They may cause discomfort but are generally not life threatening. The side effects observed with the Pfizer and Moderna vaccines mostly fall into the category of reactogenicity. These effects are rather common with mRNA and viral-vectored vaccines, such as those based on the adenovirus, and they become more pronounced with the second dose. It may also be the case that people who

have had COVID-19 have stronger reactions, even after the first dose. Reactions may also be stronger in younger populations.

There have been a very small number of people with more severe allergic reactions to the mRNA vaccines. Per Randy Hyer, reported rates for anaphylaxis after vaccination with these COVID-19 vaccines are now lower than 11/1,000,000 per a recent CDC ACIP presentation. These reactions happen within a few minutes of injection allowing for monitoring and treatment at the vaccination clinic should they occur.

As COVID-19 vaccines go into broad use, some rare side effects of vaccination will undoubtedly emerge. Stanley Perlman noted that Bell's palsy—a sudden, usually transient, weakness in one side of the face—is being monitored as one potential rare side effect of COVID-19 vaccination. In Phase III trials of the Pfizer vaccine, there were 4 occurrences of Bell's palsy in the vaccine group and none in the placebo group, while for the Moderna vaccine there were 3 occurrences in the vaccine group and one in the placebo group. This does not differ much from the background rate of Bell's Palsy in the general population, but it is definitely something to monitor.

In addition to the vaccines by Pfizer and Moderna that have already been approved for emergency use in the US, candidates from AstraZeneca (already licensed in the UK), Janssen, and Novavax are expected to release results of Phase III trials soon.

These clinical trials are part of the process—described by panelist Hana Golding—through which vaccines get approval from the FDA (Figure 4). During clinical trials, participants are added at each successive phase, going from tens of participants in Phase I to thousands in Phase III. During these trials, data on safety, immunogenicity, and efficacy are collected and evaluated. The end goal of the process is typically submission of a Biologics License Application (BLA) to the FDA for approval and licensure. This requires the company to provide information on manufacturing to assure consistency of manufacturing and quality of the product, as well as extended data on safety and efficacy over at least six to twelve months.

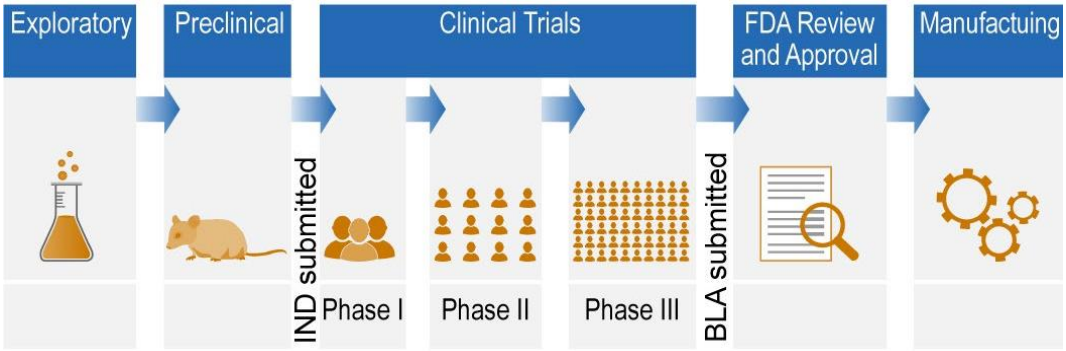


Figure 4: Stages of the vaccine approval and licensing process. (Part of a larger figure in report GAO-20-583SP.)
(Credit: U.S. Government Accountability Office from Washington, DC, United States, Public domain, via Wikimedia Commons.)

Golding emphasized that the Emergency Use Authorization (EUA) granted to Pfizer and Moderna is an unusual step put in place because of the urgency of the pandemic. EUA was granted based on review of Phase III interim data by the FDA reviewers and a panel of external experts (Advisory Committee) which gave the agency confidence in the efficacy and safety of the vaccines. Ultimately, the goal is for all vaccines used in the US to go through the full BLA licensure process.

6.5. COVID-19 is a Global Threat

Vaccination is underway in high income countries. Healthcare workers and other prioritized groups are presently being vaccinated, and vaccines will become more available to less prioritized groups throughout 2021. Karen Makar of the Bill and Melinda Gates Foundation contrasted this with low and middle income countries where:

- Vaccines will not become widely available until late 2021 or 2022.
- Population coverage will be low.
- There will be poor coverage of healthcare workers, impacting the entire healthcare system.
- Community transmission will continue and will seed ongoing local and global outbreaks.

COVID-19 modeling from Northeastern University cited in the Gates Foundation's 2020 Goalkeepers Report predicts that, if the first 2 billion doses of vaccine go to high income countries instead of distributing them proportionally to the global population, nearly twice as many people could die from COVID-19. The Gates Foundation views inequality in vaccine distribution as a looming global threat and is focused on getting vaccines to people in low and middle income countries.

The first big challenge is the number of vaccine doses needed. With seven billion people on this planet, we will need to manufacture billions of vaccine doses as quickly as possible; however, there is not currently the manufacturing capacity to do this. Makar said that we need to transfer technology and overcome regulatory hurdles to enable production in more countries. Fred Cassels described one instance where this is happening. A collaboration among Baylor College of Medicine, Dynavax, PATH, and the Indian pharmaceutical company Biological E Ltd has an RBD vaccine candidate currently in Phase I/II trials at five sites in India. This vaccine is moving toward Phase III trials that could lead to emergency use licensing, and once approved, Biological E has capacity to produce over a billion doses in a short period of time.

Pricing is another challenge. To be used in low and middle income countries, vaccines must be affordable. Finally, low and middle income countries may require higher vaccination rates to control transmission. This will add to the number of vaccine doses needed and further strain manufacturing capacity and distribution capabilities.

A second wave of vaccine candidates, such as the one from the Indian company Biological E Ltd, is necessary to supplement those currently in use in order to surmount challenges in scaling and affordability. Quoting Makar, "*It will take more than a couple of vaccines to get the job done*."

6.6. What's Next?

Adolfo García-Sastre noted that we currently have safe and efficacious vaccines against COVID-19 that are being distributed. But, this is not the end of the story.

Distribution must be accompanied by close monitoring for infections, disease, safety, and emerging new strains of the virus. Some of the questions asked by García-Sastre and other speakers include:

- Does SARS-CoV-2 change under vaccine immune pressure, potentially leading to vaccine failure or in some instances to vaccine-enhanced disease? So far, vaccine-

associated enhancement of disease does not appear to be an issue. Scientists have been unable to induce vaccine-associated enhanced disease in animal testing, and there is no evidence that it is occurring in humans. Nonetheless, the fraction of people who have been vaccinated so far is extremely small—probably not enough to determine whether there is vaccine-associated enhancement of disease. As vaccines are used more, it will become more important to monitor for evidence of vaccine-associated enhanced disease.

- As the virus changes, will we need to update vaccines? The biggest concern would be viral changes to the receptor binding site targeted by the vaccines. The new UK variant, for instance, does not seem to affect vaccine-induced immunity significantly. In contrast, studies that have occurred since the workshop was held indicate that the South African variant seems to undermine, to a certain extent, vaccine-induced immunity. Global genomic surveillance will be important for monitoring key changes in the virus. Pharmaceutical companies like Pfizer and Moderna fully expect to monitor vaccine efficacy with respect to new variants, and if warranted, updates to the present vaccine formulations will be provided. It will also be important to follow the protocols established in clinical trials to assure efficacy and avoid opening potential avenues for "viral immune escape", such as by lengthening the time between doses.
- How long does vaccine protection last?
- Why does SARS-CoV-2 spread so much more easily than SARS-CoV despite the use of the same cellular receptor?
- How much lower respiratory tract disease is present in patients presenting with mild COVID-19 symptoms?
- Which immune responses (antibodies, T-cells) are providing the correlate of protection?
- Why do we see high levels of protection after the first vaccination, before high levels of neutralizing antibodies are detected?

In closing comments García-Sastre reflected, "*This virus is very easy to neutralize. We need to realize we have been extremely lucky in terms of vaccines with this pandemic. The next pandemic, we may not be so lucky*."

7. Workshop on COVID-19 Vaccines: Distribution & Prioritization

With safe and effective vaccines becoming available in the closing days of 2020, the challenge moved from finding a vaccine to turning vaccines into vaccinations. How do we distribute the vaccines and how do we prioritize who receives them?

These were the overarching questions considered at the *Workshop on COVID-19 Vaccines: Distribution and Prioritization* held virtually on January 8, 2021. The workshop was co-organized by Dr. Fred Roberts, Director of CCICADA, Dr. Juergen Richt, Director of CEEZAD, and Maj Gen. USAF (Ret) Randy "Church" Kee, Executive Director of ADAC.

The three-hour event included two keynote presentations and two panels that collectively considered:

- Supply chain issues such as cold chain requirements for storage and transportation;
- Partnerships needed between different parts of the government and cooperation between public and private entities;
- Vaccine prioritization and related workforce issues;
- Protection against counterfeit vaccines and other types of fraud; and
- Special challenges of getting vaccines to remote areas.

The first keynote emphasized coordination and partnership and was delivered by General Joseph Votel, CEO of Business Executives for National Security (BENS), a national, nonpartisan, nonprofit organization comprised of senior business leaders who volunteer their time and expertise to assist the US national security community. In the second keynote, Dr. Brian Strom, Chancellor of Rutgers Biomedical and Health Sciences and the Executive Vice President for Health Affairs at Rutgers, provided a broad overview of the highly dynamic state of vaccine rollout.

The first panel offered perspectives from people working in different aspects of vaccine development and distribution. Panelists were Dr. David Adinaro, Deputy Commissioner of Public Health Services in the New Jersey Department of Health, Dr. Kevin Ban, Chief Medical Officer at Walgreens, Karin Shanahan, Senior Vice President for Global Biologics and Sterile Operations at Merck, and Marion Whicker, Deputy Chief of Supply, Production and Distribution for Operation Warp Speed.

The second panel addressed some of the compounding challenges faced in vaccine distribution. These include criminal activity, reduced transport capacity because of grounded passenger flights, and getting vaccine to the nation's most remote areas. Participating on the panel were Len DeCandia, Chief Procurement Officer at Johnson & Johnson, Brandon Fried, Executive Director of the Airforwarders Association, Reggie Jackson, Senior Manager for Supply Chain Security at Pfizer, Jere Miles of DHS Homeland Security Investigations, Ted Smith of the Alaska Native Tribal Health Consortium, and Shellie Martin of the Kodiak Area Native Association.

Controlling the pandemic rests on three key pillars: 1) public health interventions to reduce the spread of COVID-19; 2) rapid development of safe and effective vaccines and therapies; and 3) coordinated distribution of vaccines (and therapies) to where they are needed. The workshop largely focused on the third pillar and the multi-faceted challenges of vaccine distribution.

Keynote Speakers:

- General Joseph Votel**,** CEO, Business Executives for National Security
- Dr. Brian Strom, Chancellor, Rutgers University Biomedical and Health Sciences

Panel on Distribution, Allocation, Administration, and Roles of Government and the Private Sector:

- Dr. David Adinaro, Deputy Commissioner of Public Health Services, New Jersey Department of Health
- Dr. Kevin Ban, Chief Medical Officer, Walgreens
- Karin Shanahan, SVP, Merck
- Marion Whicker, Deputy Chief of Supply, Production and Distribution, Operation Warp Speed

Panel on Supply Chain Issues:

- Leonardo (Len) DeCandia, Chief Procurement Officer, Johnson & Johnson
- Brandon Fried, Executive Director, Air Forwarders Association
- Reggie Jackson, Senior Manager Supply Chain Security, Pfizer
- Jere Miles, Department of Homeland Security, Homeland Security Investigations
- Edward (Ted) Smith, Alaska Native Tribal Health Consortium
- Shellie Martin, Kodiak Area Native Association

7.1 Coordination & Cooperation

Gen. Votel's keynote stressed the need for *cooperation* and *transparency* across levels of government and the private sector for smooth distribution of the materials, manpower, and supplies needed to get people vaccinated.

Votel described some of the findings and recommendations of a commission formed by BENS to review existing policies and procedures for pandemic response and to identify key areas for improvement, not just for the current pandemic but for future emergencies of a national scale. The BENS commission sought to define current and ideal states for managing a pandemic response and to identify existing gaps that need to be closed in order to mount an ideal response. Working groups within the commission conducted over 200 interviews with leaders across sectors, focusing a major portion of their effort on "surge and supply"—having the right materials and getting them to the right place at the right time.

The commission identified a series of overlapping gaps in our pandemic response, including:

- Weak command and control driven by a lack of infrastructure connecting critical stakeholders, leading to confusion over jurisdiction, priorities, responsibilities, and partnerships.
- Lack of sustained public-private engagement with very little wargaming, resulting in inadequate emergency preparedness.
- Limited supply chain visibility leading to confusion about availability of resources, supplies, and personnel.

With respect to the above points, other speakers offered specific examples. Panelist Karin Shanahan of Merck addressed the lack of supply chain visibility and noted, "*With limited information, companies work to protect their patients, sometimes exacerbating shortages*." She said that when companies noticed delays and shortages at the start of the pandemic, they often expedited or increased orders, further straining the already-stressed supply chain. By the middle of 2020, there were complete shortages of some single-use components, syringes, and other key ingredients. "*Ultimately, we were all trying to do the same thing—protect patients—but very quickly we were working against each other. How do we create the type of visibility that allows industry to holistically look at supply position?*"

In his keynote, Dr. Brian Strom offered the example of vaccine shortages, in part worse because both federal and local agencies and even health systems are holding back doses for second shots. Whereas Shanahan illustrated shortages driven by lack of transparency, Strom's example shows the link between shortages and weak command and control.

In a then-forthcoming report, the BENS commission describes key findings, summarizes gaps identified, and makes several specific recommendations to bridge these gaps. One such recommendation is to designate a leadership position within DHS to prioritize and oversee exercising and testing of emergency response plans.

7.2 Vaccine Pipeline

Strom's keynote offered an overview of the rapidly changing state of the pandemic, the vaccine pipeline, and vaccine distribution.

In describing the vaccine development for COVID-19, Strom said, "*Vaccine development typically takes 73 months. It was done incredibly fast and incredibly well in Operation Warp Speed, getting the first vaccines in 14 months*."

Operation Warp Speed (OWS) was a partnership of the Department of Health and Human Services (HHS), Department of Defense (DoD), and other federal organizations to develop, manufacture, and deliver COVID-19 vaccines. Panelist Marion Whicker of OWS noted that delivering a vaccine in 14 months required that steps in the development process that would typically be done sequentially be done concurrently. Notably, this included beginning to manufacture vaccine doses while Phase 3 trials were ongoing—exposing a substantial financial risk borne by the federal government to expedite development. Panelist Len DeCandia of Johnson & Johnson cited additional examples of parallelizing the supply chain in anticipation of the vaccine. These include work done to expand capacity for producing critical elements like glass vials and even dry ice. There were also parallel efforts in planning for smart packaging to monitor temperature and enable tracking.

The Pfizer and Moderna vaccines that are now in use are highly effective, with efficacies of 94-95%. Nevertheless, they present supply chain issues, both because of cold storage requirements and the two-dose regimen. Other leading candidates for Emergency Use Authorization (EUA) and distribution in the US include a vaccine by AstraZeneca that is already in use in the UK, as well as one by Johnson & Johnson that has since been approved for emergency use. The J&J vaccine is a single-dose vaccine without the stringent cold chain requirements. These features will make it easier to distribute, especially to hard-to-reach places.

> *"Every state was starting from scratch, and every state has been doing it in a different way."* Dr. Brian Strom, Chancellor, Rutgers Biomedical and Health Sciences

7.3 Some Bumps in the Rollout

Vaccination against COVID-19 began in the US on December 14, 2020. By the time of the January 8th workshop, roughly 4.8 million people had been vaccinated—far short of the goal of 20 million by the start of 2021. (That goal was ultimately passed on January 23.)

In Strom's words, "*Lack of infrastructure and politics led to a varied and lengthy implementation period by federal, state, local governments*."

Public health in the US is highly decentralized. The CDC's Advisory Committee on Immunization Practices (ACIP) provides advice and guidance to the Director of the CDC regarding use of vaccines and their prioritization. These recommendations are passed to the states and then left to the states to implement through county health departments. Unfortunately, these state and local agencies are ailing. As Strom put it, "*The public health infrastructure has been gutted over the last decade, but especially in the last four years, and CDC has lost*

credibility over the last four years." The lack of leadership and direction from the CDC led to inadequate advanced preparation by the states and large differences in how vaccines were rolled out. Again, quoting Strom, "*Every state was starting from scratch, and every state has been doing it in a different way*." In New Jersey, the rate-limiting elements in the initial rollout were planning, logistics, and most of all, manpower. Later, supply became the limiting factor.

In essence, the initial rollout revealed many of the gaps that Gen. Votel identified—weak command & control, lack of infrastructure, and inadequate planning—all compounded by overlap with the end-of-year holidays.

7.4 Vaccine Allocation & Prioritization

During the time of limited supply in the initial rollout, prioritizing who receives the vaccine was perhaps the most visible and consequential decision. In December 2020, CDC's ACIP issued its first recommendations on prioritization. The recommendations weighed benefits and risks to different populations, feasibility of delivery, and adherence to ethical principles that included promoting justice and mitigating health inequalities. ACIP's recommendations for Phase 1 were:

- Phase 1A: Healthcare workers and long-term care residents and staff.
- Phase 1B: Frontline essential workers, such as police and firefighters, and persons aged 75 or over.
- Phase 1C: Other essential workers, such as transportation workers, persons 65 or over, and those with increased medical risk.

Phase 2 would see expanded supply of vaccine accompanied by broader access to the general population.

These recommendations provided guidance to the states, but each state determined its own prioritizations, and they varied greatly. For example, many counties in Florida opened vaccination to all people 65 and over, without further prioritization, even for medical workers. New Jersey, on the other hand, adhered more closely to ACIP's recommendations. Panelist David Adinaro of the NJ Department of Health described NJ's process, which prioritized healthcare workers and long-term care residents in Phase 1A and moved to include frontline essential workers to start Phase 1B (which was just underway at the time of the workshop).

7.5 Vaccine Distribution

Adinaro noted that, although there were some early glitches in the distribution process, things had gotten smoother by the time the workshop was held. Nonetheless, he was concerned about assuring future delivery of vaccines to meet requests from vaccination sites.

Each week, the federal government allocated vaccine doses to 64 jurisdictions (primarily states and territories) and 5 federal entities proportionate to population. Operation Warp Speed (OWS) was central to distributing them. In addition to speeding up the vaccine development process, mentioned above, OWS helped to bolster manufacturing capacity and to secure ancillary supplies, such as syringes and glass vials. It was also responsible for coordinating the distribution of the vaccines that are allocated to states and other entities.

Figure 5 illustrates the OWS distribution process described by Marion Whicker. The process relied on McKesson, a large commercial medical distributor, to serve as the central distributor of vaccines and ancillary kits to end use locations, such as hospitals and pharmacies, via

commercial carriers, such as UPS and FedEx. The only exception being Pfizer, which sent directly to carriers for delivery to end use locations as shown.

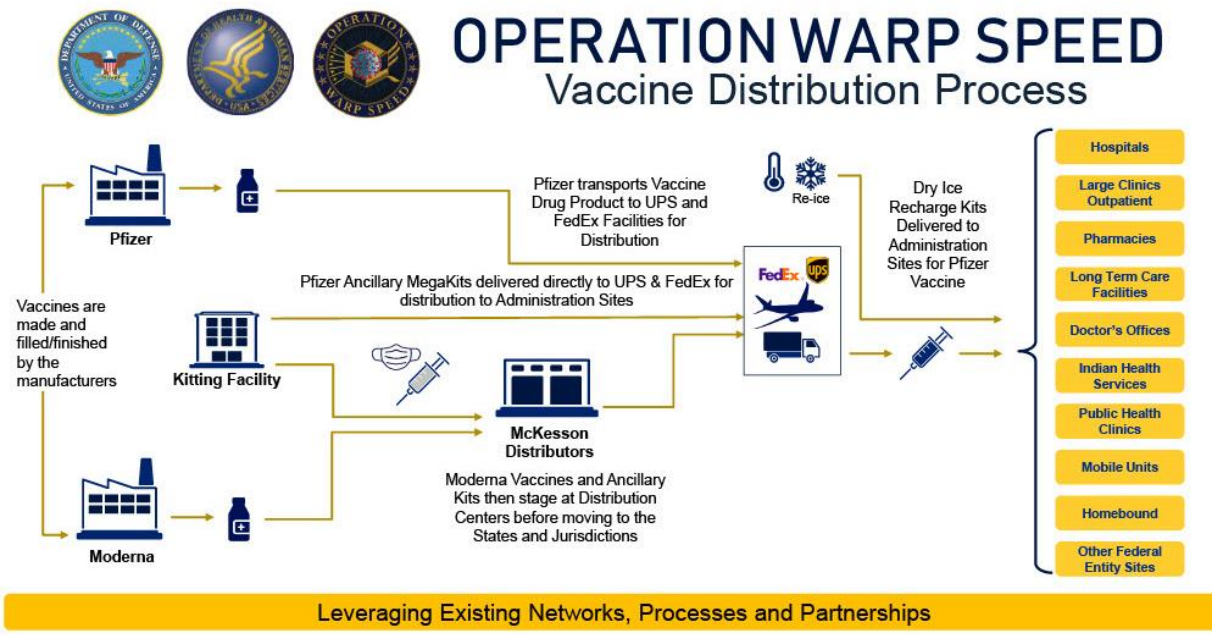


Figure 5: Operation Warp Speed has a streamlined distribution process. Credit U.S. Department of Health and Human Services.

7.6 Air Cargo

Air transport is essential to distributing vaccine doses around the world. Panelist Brandon Fried of the Airforwarders Association cited figures from International Air Transport Association quantifying the potential scale of the endeavor: delivering a single dose to over seven billion people would fill 8,000 747s. Even if half are delivered by land, it's still a tremendous amount of air cargo. The supply chains for vaccine production and the need for ancillary supplies to support the vaccine campaign (syringes, etc.) would add to the volume of vaccine-related cargo.

Transporting COVID vaccines by air presents a number of challenges:

- The pandemic reduced the cargo capacity available on commercial flights. Quoting Fried, "Shortly after the pandemic began, most passenger airlines parked their planes because of lack of demand. This resulted in loss of 50% of the world's cargo capacity." Some airlines began using their fleet to fly cargo-only flights, or flew cargo in unused seats. United Airlines flew over 10,000 such flights in the month preceding the workshop.
- Extra-cold storage requirements limit how much vaccine can be transported because of limits on how much dry ice can be carried on a flight.
- Vaccines are a high-value item, so the entire supply chain may be targeted for both cyber and physical attack.

7.7 Protecting the Product

Panelist Reggie Jackson spoke about steps that Pfizer put in place to protect vaccine efficacy and prevent counterfeiting and fraud as the vaccines made their way from manufacturing to the ultimate recipients.

As mentioned previously, Pfizer ships its vaccines directly to points-of-use via UPS or FedEx. Doses are shipped in specially designed, temperature-controlled thermal shippers that use dry ice to ensure that the ultra-cold temperatures can be maintained for up to ten days unopened. Pfizer has security measures in place to determine the location of its vaccine shipments. If a shipment deviates from its pre-set route the Pfizer security team is notified immediately.

Secure shipping containers and direct distribution via trusted carriers protects the product enroute, but manufacturers also need to protect against counterfeiting and fraud. Jackson noted that the Pfizer vaccine is only available through dispensers such as state health agencies, hospitals, and pharmacies. It cannot be purchased online. Nevertheless, offers to sell the vaccine do appear online, and there is a Pfizer security team that works to find them and have them taken down.

Jackson also said that Pfizer has anti-counterfeiting features in place to make it difficult to manufacture a counterfeit product or label. After vaccines are used, Pfizer works to assure that vials are destroyed to prevent use of legitimate vials with counterfeit product.

Panelist Jere Miles of DHS Homeland Security Investigations said that a lot of pandemic-related fraud is cyber based. Early in the pandemic, there were sales of fraudulent cures for COVID-19. Later, this moved toward homeopathic remedies that claimed to provide unproven benefits. In both cases, purchasers would receive a product, albeit one with no proven benefit. More recently, scammers began selling products for payment online but with no intention of delivery. The resulting transaction is just an online payment, affording the "seller" little exposure to US law enforcement. These cyber criminals are able to quickly adapt their "business," making it difficult for law enforcement to stay ahead of them. So, it's good to remember Jackson's warning, "*This vaccine is not available online*."

7.8 The Last Mile

Once the vaccines are delivered to a provider, the final challenge lies in delivering shots to arms.

Whicker described OWS as taking a "whole of America" approach leveraging partnerships to combat the pandemic. Through one such partnership, CVS and Walgreens administered vaccines to those in long-term care facilities, bringing the vaccine "the last mile". Dr. Kevin Ban of Walgreens said the company worked closely with OWS and the CDC and is now working with the states to leverage the power of a respected pharmacy within the community to educate people about the pandemic, provide testing, and now administer the vaccine. Ban said, "*While this vaccine is new, the model for delivery by Walgreens is not new. Walgreens has been building its vaccine program over the last ten years.*" Walgreens expected to have vaccination in most of its long-term care facilities completed by late February or early March 2021 and was laying plans for vaccination of the general population.

To vaccinate the general population, Adinaro said, "*We need to get this vaccination close to where people live and work*." In NJ, this meant vaccinating at locations that include a mix of county health facilities, "mega-sites," hospitals, urgent care centers, physician's offices, and retail pharmacies, as well as mobile sites to serve hard-to-reach, at-risk populations.

Panelists Ted Smith and Shellie Martin illustrated that closing the last mile is not so easy in remote areas of Alaska. Martin is a community health aide with the Kodiak Area Native Association (KANA) who travels between five remote villages in the Kodiak archipelago to provide primary health care and after-hours emergency services to their residents. In this role,

she had helped to administer over 300 vaccine doses, but getting the vaccines into arms was not so easy.

The villages that Martin serves have populations ranging from 25 to 220 and are accessible only by plane or boat…weather permitting. For the two weeks preceding the workshop, winged aircraft had been unable to reach the villages because of high winds, so Coast Guard helicopters flew in vaccines she administered to the native population. Non-native populations in these remote areas needed to travel to the city of Kodiak for vaccination.

The U. S. Coast Guard delivers vaccines to Akhiok village (pop. 25) in Alaska.
Photo credit: Donene Amodo, Akhiok, Alaska

7.9 Herd Immunity

The ultimate goal of a vaccination campaign for a highly transmissible disease like COVID-19 is achieving herd immunity. Vaccination provides a path to herd immunity but requires high vaccination rates. That rate varies by disease—for measles it is 90%. It is too early to know what will be required for COVID-19, but past experience suggests that it will be upwards of 70%.

One obstacle to achieving herd immunity is vaccine hesitancy. Hesitancy arises, among other things, from concerns about safety and side effects, as well as a fundamental mistrust of the medical establishment and government, which in the case of COVID-19, has been exacerbated by politicization of the surrounding public health crisis.

Globally, the percentage of people expressing willingness to take the vaccine hovers around 70%, but varies widely by country (Figure 6). In the US, about two-thirds of the population—less than what is likely needed for herd immunity—express willingness to be vaccinated. Strom noted that this hesitancy is already apparent, "*What we are finding, even among healthcare workers, is that there are a lot of people*

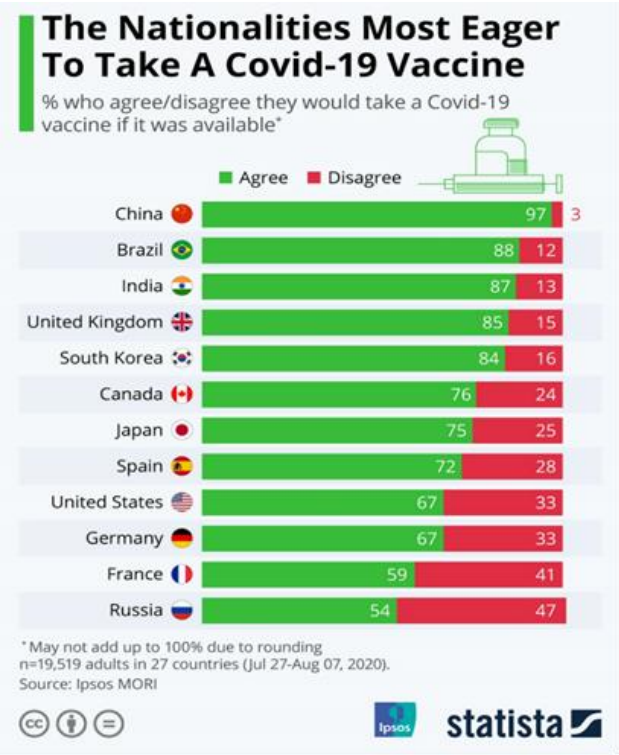


Figure 6: Roughly a third of the US population is hesitant to take the vaccine.

who are afraid to take the vaccine, particularly people in minority populations and the underprivileged who most need it." Drs. Adinaro and Ban confirmed this hesitancy, but Ban also cited tremendous positive energy at vaccine clinics, which have been met with applause and even dancing.

Novel virus variants are another challenge to achieving herd immunity. As the virus evolves and mutates, particularly in the genomic areas targeted by the vaccine, it may reduce vaccine efficacy. Variant strains of the virus are already surging in the UK, South Africa, and Brazil and are making their way around the world. While there is optimism that the vaccines will work on most of these variants, the effect of the mutations on vaccine efficacy are still largely unknown.

8. Workshop on the Suez Canal Incident: Impact and Implications for the Global Maritime Supply Chain

With global supply chains slowly recovering from system-wide impacts of the ongoing pandemic, they were confronted with another challenge—a massive container ship blocking one of world's busiest shipping lanes. On March 23, 2021, the 400-meter Ever Given ran aground while transiting the Suez Canal in gusty winds. It became wedged in the canal, and blocked traffic in both directions for six days.

The six-day closure stranded more than 400 vessels, leaving them to either wait it out or reroute around the Cape of Good Hope which would add more than a week and considerable cost to the journey. The closure would also have lingering supply chain effects layered on top of those already felt from COVID-19, such as container shortages, port congestion, and spikes in freight rates and energy prices. A longer blockage would have certainly been more disruptive, raising concerns about how to handle complex supply-chain challenges of long-term importance.

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

Examining the Suez incident provides a unique opportunity to identify emerging global supply-chain factors, improve preparedness, enhance business continuity, and prioritize future research and policy decisions.

With this background, Dr. Fred Roberts, Director of CCICADA, Maj Gen, USAF (Ret) Randy "Church" Kee, Executive Director of ADAC, Dr. Adam Rose, Director of CREATE, and CAPT Andrew Tucci (USCG, Ret) organized the *Workshop on the Suez Canal Incident: Implications for the Global Maritime Supply Chain*.

The workshop included a keynote presentation by Rear Admiral (RDML) Brian Penoyer of the US Coast Guard followed by three panel sessions. The panelists who followed collectively

represented decades of experience overseeing some of the nation's largest ports and waterways, as well as some of its most remote. They considered questions such as:

- What are the challenges presented by a disruption like the Suez Canal blockage? When the Suez Canal incident occurred, the global supply chain, which is dominated by maritime traffic, was already impacted by the COVID-19 pandemic. How did that make the impacts of the incident worse?
- Malicious actors, natural disasters, pandemics, geo-political events and marine casualties such as the Suez event can disrupt domestic and global supply chains. These and other disruptions can occur singly or in combination. While supply chains may be resilient enough to cope with a wide variety of single disruptions, aggregated challenges may result in cascading failures, well beyond the ability of many organizations to address. How do multiple, interconnecting disruptions of global supply chains produce outcomes that are much more complicated and challenging than those of single disruptions, and how can we best prevent them, prepare for them, respond to them, and recover from them?
- Will economic behaviors return to pre-pandemic states or are changes long-lasting?
- Our nation's homeland security is linked to global maritime trade. What lessons have we learned from the Ever Given incident that will help us be prepared for future disruptions to the marine transportation system?

Keynote Speaker:

- Rear Admiral Brian Penoyer**,** United States Coast Guard

Overview Panel:

- Capt. David Moskoff, United States Merchant Marine Academy
- Sam Ruda, Director, Port Department, Port Authority of New York & New Jersey
- Capt. Lawson Brigham, United States Coast Guard (retired)
- Capt. Andrew Tucci, United States Coast Guard (retired)
- Henry Willis, Homeland Security Operational Analysis Center

Panel on Impacts of the Suez Disruption and other Multiple, Complex Disruptions:

- Gabriel Weaver, Research Scientist, Critical Infrastructure Resilience Institute (CIRI) COE
- Brandon Fried, Executive Director, Airforwarders Association
- Capt. Eric Johansson, SUNY Maritime College
- Capt. Zeita Merchant, United States Coast Guard

Panel on Types of Disruptions, Present and Future, Mitigation and Response:

- Capt. Phil Thorne, United States Coast Guard (retired)
- Bethann Rooney, Deputy Director, Port Department, Port Authority of New York & New Jersey
- Casey Hehr, Director of Security, Port of Long Beach, California
- Capt. Eric Johansson, SUNY Maritime College
- Kim Young-McLear, Cybersecurity and Infrastructure Security Agency & U.S. Coast Guard

8.1. Port Congestion and the Post-Pandemic Economy

The workshop's keynote speaker, Rear Admiral Brian Penoyer, described the impacts of the pandemic and the subsequent reopening of the world's economies on the marine transportation system (MTS). At one point, because of delays at the ports of Los Angeles-Long Beach and resulting spillover to Oakland, San Francisco Bay was filled with containerized shipping waiting to dock—a scene no one can remember seeing.

The cargo spike and resulting port congestion can be at least partly attributed to the pandemic. With economies bouncing back from the pandemic, there is a major push to restock and rebuild. The demand for imports is not just coming back. It is at a much higher level, indicating what may be a fundamental shift to online commerce that was borne of necessity during the pandemic and still persists. During the pandemic, the economy became further "Amazonized" with more shipping, but there has been little change in global containerized-shipping capacity to match. Adding to the surge in imports, exports are also up, especially of agricultural products from California and petrochemical products. The result of all of these factors is congested ports and shipping delays.

The Port of Long Beach, together with the Port of Los Angeles, forms the busiest port complex in the US and the ninth busiest in the world. Panelist Casey Hehr, Director of Security at the Port of Long Beach, said that the Suez Canal incident has highlighted some of the issues facing the port, which are exacerbated during disruptions. For example, as demand grows, the number of containers available for manufacturers has not been adequate. The Port of Long Beach had a record volume last year, and he predicted more and more backups if the demand for imports continues apace. Hehr noted that China accounts for 60% of the container cargo imported into the port. As people build or rebuild houses, a great deal of what goes into them is from China. He said that ports and manufacturing in Asia operate 24 hours a day, 7 days a week. By comparison, the Port of Long Beach is not typically a 24/7 operation, nor are the supporting logistics required to move and store imports. These operational differences also contribute to backups at the port.

Panelists Sam Ruda and Beth Ann Rooney, both of the Port Authority of New York/New Jersey, reported that the Ports of NY and NJ also saw large increases in cargo volume over the same period. Before the pandemic, supply chains had become very efficient because of "just-in-time" technology, an inventory and production policy driven by a desire to minimize costs and enabled by artificial intelligence and machine learning. Under relatively stable conditions, it allows companies to accurately anticipate demand to reduce inventory costs. It works well until there is an anomalous event such as a pandemic. Rooney observed that, in the wake of large-scale disruptions during the pandemic, shippers and merchants ramped up shipments "just-in-case" there are future shutdowns, moving from a "just-in-time" policy to a "just-in-case" view that has them pouring additional cargo into the country just in case there is another global shutdown. According to Rooney, there was five years' worth of growth in cargo volume in five months, and that is not sustainable.

While we may expect industry to gradually revert back to just-in-time, we must consider what consequences can we expect from the next disruption (or series of disruptions) and what modifications to just-in-time methods might make global supply chains more resilient. These are among the research topics coming out of the Workshop.

The Suez Canal incident occurred in the context of this "post-pandemic economy." Still, we might ask whether things will go back to a pre-pandemic conditions or whether the changes

long-lasting. And what will be the effect on the MTS? These questions are central to understanding how the MTS will handle future disruptions.

8.2. Resilience

Admiral Penoyer said that, for the 15 months during the pandemic, the US Coast Guard has focused on resilience, including resilience of the maritime transportation system (MTS) and global shipping industry. He noted that the supply chain is more accurately depicted as a network that can find alternate pathways if an individual node (such as an individual port facility) becomes unavailable.

Early in the pandemic the cruise ship industry was hit hard. Communities were reluctant to accept ships with known or suspected COVID cases, and existing cruise ship passenger terminals were ill suited to accommodate the social distancing and other health procedures needed to reduce risk. The first cruise ship to reach the US was the Grand Princess, waiting off of San Francisco with confirmed positive cases on board. Nearby hospitals were over-run and short of supplies, and the ship could not come into its normal berth, so the Coast Guard facilitated the use of an alternate port facility where screening, vetting, and medical intervention could take place. This required coordination across various maritime and public health entities. Hospitals became part of the supply chain for cruise ships during the pandemic. Although the original node—the designated passenger terminal—was unequal to the challenge, the network, including non-maritime organizations, provided the resilience needed to resolve the situation safely. The important distinction is that, in supply chains, node resilience and network resilience are different.

When vessels were waiting for the Suez Canal to reopen, there was an alternate route to consider—around the Cape of Good Hope at the southern tip of Africa. The detour would add 8 to 9 days to the voyage, but it was hard for carriers to decide whether to take the longer route because of the unpredictability of the delay, especially in the early stages of the response. As RDML Penoyer noted, delays in the supply chain can be tolerated if they are predictable**.** To a large extent some level of disruption is always occurring and can therefore be arguably labeled as "predictable." Unusual events can be "predictable" to the extent that government agencies and others share information on how an incident is being managed, allowing industry to make alternate plans. Despite the unusual and high-profile nature of the Suez incident, it was resolved within six days. The node and network aspect of the global supply chain provided the resilience necessary for the system as a whole, despite the impact to individual cargo owners.

Nonetheless, even a resilient network has its limits, especially if disruptions exceed the built-in resilience that the network has adapted to over time. RDML Penoyer gave the example of the Houston Ship Channel. Although the Coast Guard cannot promise to always keep the passage open, it has been able to limit closures to no more than five days, even in the event of oil spills, ship collisions, and hurricanes. This offers considerable predictability about the extent of a disruption, and the systems used to manage today's supply chains can take such levels of delay into account. In short, some level of predictability contributes to resilience**.** However, disruptions greater than five days would likely exceed the reserve capacity of refineries and other nodes in the energy sector, leading to more severe consequences and unpredictable impacts in other areas of the trade network and greater economy.

8.3. The Anatomy & Impacts of the Incident

With the MTS already straining under large cargo volumes generated by reopening economies, it was confronted with another challenge—a massive container ship blocking the Suez Canal, one of the world's busiest shipping lanes.

The Suez Canal connects the Red Sea with the Mediterranean, providing the shortest year-round route between Europe and Asia. In 2020, nearly 19,000 ships carrying over a billion tons of cargo and representing about 12% of global trade passed through the canal. An estimated $400 million of goods transit the canal each hour. By any measure, it is a critical waterway and one of the world's critical chokepoints—a single point of failure that makes many supply chains vulnerable, according to Brandon Fried, Executive Director of the Airforwarders Association. CAPT David Moskoff of the US Merchant Marine Academy provided some insight into how an incident like the Ever Given accident can happen. To begin, he noted that the Suez Canal was built in 1869 and designed for fairly small ships. At 400 meters in length, 59 meters in width, and carrying 200,000 tons of cargo, the Ever Given is huge. And such ships keep getting bigger. Just since 1968, the container-carrying capacity of ships has increased by over 1500% and has almost doubled in the past decade. It is reasonable to wonder if the Canal is still adequate in this context.

The Ever Given is one of the world's largest container ships--nearly a quarter mile in length and able to carry 20,000 containers. Credit: Robert Schwemmer for NOAA's National Ocean Service, CC BY-SA 2.0, via Wikimedia Commons

CAPT Moskoff suggested that many factors likely contributed to the accident: the ultra large size of the ship; the fact it had a single propeller; wind (strong gusts); the ship's speed; the lack of an escort tug made up to the ship; and the hydrodynamics of the canal.

At the time of the workshop, the Ever Given remained in the Suez Canal—no longer blocking traffic but unable to continue pending settlement negotiations. Sam Ruda, Port Director at the Port Authority of New York/New Jersey, observed that vessel owners, charter parties, and vessel operators need not be one and the same. This leads to bifurcated and complex identification of "responsible party" accountability if/when a crisis occurs. Another factor in the delayed resolution of the incident, according to Brandon Fried, was the multi-national makeup of the stakeholders. The MV Ever Given was owned by a company in Japan, operated by a container shipping firm based in Taiwan, managed by a German company, and registered in Panama, with 26 crew members from India.

Ruda said that among the lessons learned from the incident were the needs to develop/establish:

- Pilot training on 16,000+ TEU class vessels, including use of simulators in training;
- A protocol for tug deployment: how many and under what conditions?;
- Requirements for "back-up" resources in case of vessel-related issues: tugs, private dredge fleet, ACOE dredge fleet, etc.; and
- A resiliency protocol in constrained navigation channels.

CAPT Moskoff considered how we might lower the probability of similar accidents in the future and listed a number of measures:

- Making the canal deeper and wider (dredging is under way);
- Requiring tugboat escorts (faster, more powerful tugs);
- Improved (and improved access to) weather monitoring (and corresponding control of traffic);
- Requiring specific training in how to safely navigate the Suez Canal and/or similar bodies (using live models and simulators);
- Establishing improved (and specific) transit management practices (better delineation of pilots, vessel monitors on board); and
- Creating qualified and competent audit teams (to provide regular monitoring of vessels).

CAPT Zeita Merchant, Commander of USCG Sector New York, said that 45% of the traffic heading for the port of New York/New Jersey transits the Suez Canal. Thus, one could have expected a significant impact of the Suez Canal blockage. Yet, Sam Ruda said that the Suez Canal incident had a small, short-lived impact in the New York/New Jersey area. There were 11 vessels heading to New York/New Jersey that were impacted; five chose to go around the Cape of Good Hope. Within three weeks, all affected vessels had arrived and departed. One vessel changed its order of port arrivals, going first to the Port of Norfolk. The impacts of delays in cargo delivery were basically resolved in three weeks. Bethann Rooney of the Port Authority called this impact insignificant and pointed out that, in the container shipping world, ships are off schedule 65% of the time. The Suez incident just added to this slightly.

Nonetheless, retired US Coast Guard Captain Andrew Tucci pointed out that the incident could have been much worse. The incident occurred while the size of the daily tides was still rising; this meant that the Canal had increasing depths of water during the response, helping to refloat the ship. Had the opposite been the case, the incident would have lasted longer, perhaps even requiring cargo to be unloaded to lighten the vessel. The result would have been an enormously complex and time-consuming operation. So, while the incident was significant (it delayed more than 400 ships after all), a worst-case scenario would have been much more disruptive and costly.

8.4. The Arctic Route Is Not a Suitable Alternative

The Northeast Passage across the top of Eurasia for shipping from Asia to Europe has been touted as an alternative because it is a shorter distance than more southern routes. The Northern Sea Route (NSR) Russian national Arctic waterway, extending from the Kara Sea to Bering Strait, is viewed by some in the Russian Federation as a viable alternative for global shipping between East Asian and European markets. This is at least partly because of the increase in marine access created by the profound retreat of Arctic sea ice. Currently, the NSR is seeing seasonal increases in destination traffic (not trans-Arctic voyages) primarily by icebreaking Liquified Natural Gas (LNG) carriers and icebreaking tankers transiting bulk product from LNG and oil terminals in Ob Bay along the Yamal Peninsula. These cargoes are mainly headed to ports in China, Japan, and Korea.

Maj Gen (Ret) Church Kee, Executive Director of the ADAC COE, noted that in the aftermath of the Suez Canal mishap, Russian Federation President Putin messaged the Global Maritime Community extolling the value of shipping via the NSR as a useful alternative to transiting from Asia to Europe via the Suez Canal. However, according to CAPT (Ret). Lawson Brigham, now on the research faculty of the University of Alaska Fairbanks, the Arctic Ocean is not a solution for the global maritime transportation system for global container shipping. The Northeast

Passage, NSR, or any other Arctic routes are not substitutes for the Suez and Panama canals. Arctic sea-ice coverage has been steadily decreasing since the early 1980s, but the Arctic basin will remain ice covered during the colder months (October to May). During these times, most of the Arctic is impassible by normal ocean vessels. Projections indicate that—even by as late as 2050—the Arctic Ocean will remain largely ice covered for 6 to 8 months a year. Thus, most Arctic routes will likely be seasonal at best, except for the most ice-capable of ships.

In order to negotiate ice-covered waters, vessels have to reduce transit speed, negating the advantage of shorter distance in the Arctic Ocean. Passage through ice-covered waters usually necessitates the use of specialized ships (that are ice-breaking or ice-strengthened). Notably, all commercial ships intending to operate in the Arctic Ocean must meet the broad marine safety, environmental protection, and marine experience/training requirements of the mandatory International Maritime Organization (IMO) Polar Code. Currently, there are a small number of world-class, Arctic-capable ships (mostly bulk carriers) that meet the rules and regulations of the Polar Code. However, the overwhelming number of today's huge container ships are not constructed, equipped, or manned with Arctic mariners to enable operating in the Arctic Ocean.

CAPT Tucci observed that the remoteness and lack of infrastructure would make any event happening in the Arctic significantly more difficult to resolve than a similar event in a place like the Suez Canal or the Port of New York. CAPT Phil Thorne (USCG, Ret, now USCG District 17 Arctic Program Specialist) highlighted the many challenges facing marine traffic in the Arctic:

- Limited infrastructure
- The tyranny of distance
- Minimal communications
- Sparse resources
- Extreme/unpredictable weather
- Reduced government response capability.

All of these factors increase the cost and risk of passage, making the Arctic an unattractive choice for routine traffic, despite the reduced distance. To date, essentially all Arctic shipping has been related to the movement of cargo (or cruise ship passengers) to or from the Arctic, rather than as an alternative to non-Arctic voyages.

A variety of international forums exist to reduce Arctic risks. These include the IMO and international collaboration with Arctic nations such as Russia and Canada. The IMO's Polar Code includes human factor rules, polar certificates, and polar manuals of operation. But, per CAPT Brigham, human factors are a limitation—not many mariners have polar ship experience. Moreover, technology is not necessarily a solution. A new design for an ice-breaking container ship might be feasible for ships carrying up to 8,000 boxes but not the 20,000-box capacity of the Ever Given.

CAPT Thorne called for more research on the direct effects of the physical environmental change and the speed with which it is happening. He also called for more research on the second order (and higher order) effects of such change.

8.5. Envisioning Complex Interconnected Incidents

There are a variety of chokepoints in the global maritime transportation system. In addition to canals, narrow channels pose similar risks to some of the country's busiest ports. Sam Ruda pointed out that the Port of New York and New Jersey has its own chokepoint—the Kill van Kull (KVK) navigation channel that runs between Jersey City, New Jersey to the north and Staten Island, New York to the south, as shown in Figure 7.

Figure 7: The Kill Van Kull is a narrow strait with Bayonne NJ to the north and Staten Island NY to the south. Credit: OpenStreetMap contributors, CC BY-SA 2.0, via Wikimedia Commons

CAPT Merchant said that 80% to 90% of the region's goods travel through the KVK. As such, it is an area of great focus for the US Army Corps of Engineers, US Coast Guard, and Port Authority of New York/New Jersey. Bethann Rooney said that they have systems in place to prevent an Ever Given type event and also have the ability to respond quickly. CAPT Tucci mentioned the container ship Golden Ray that capsized off the coast of Georgia in 2019 and for which the salvage operation is still ongoing. He said that if a similar incident were to happen in the Kill van Kull, it would be a major issue.

While we heard from speakers that the Suez Canal incident had relatively minimal and short-term impacts on particular US ports, we also heard CAPT Tucci caution that the impact of the event could have been large. We may not be as lucky the next time, especially if a chokepoint blockage occurs in the context of a cyberattack or a hurricane, a labor stoppage, or another major disruption.

CAPT Merchant told us that after the Suez incident, stakeholders of the Port of New York/New Jersey held a roundtable discussion to validate current prevention/risk management efforts, identify unmitigated areas of concern and potential "worst-case" scenarios, share potential impacts of prolonged waterway closure, and discuss adequacy of existing response/salvage resources to execute recovery. Among the multiple, complex disruptions discussed were combinations of pandemics, cyberattacks, natural disasters, active shooter events, congestion challenges, and unmanned aerial systems. She talked about how a cyberattack could turn into an oil spill and how the threats we face in the cyber domain will soon equal or surpass the physical threats managed daily. She referenced the Colonial Pipeline ransomware attack and wondered what the implications would be of such an attack on the OT (operational technology) systems in addition to the IT systems. As Capt Tucci said, research is needed to understand such complex, interconnected events and how to prepare, prevent, respond to, and recover from them.

Kimberly Young-McLear, who is on assignment to CISA from the USCG, also highlighted cyber as a major concern in the maritime domain. She described MTS cyber risks in facility access; to terminal HQ data; to operational technology (OT) systems; to position, navigation, and timing; and to vessels. Further, she addressed the increasing vulnerabilities and rising costs to the MTS from ransomware attacks by criminal actors.

Young-McLear discussed the resilience of cyber systems with an emphasis on system agility and responder agility, mentioning the importance of cognitive delay and cognitive misjudgment. Human factors are so important in cyber security, and there is need to train to account for the increasing complexity of cyber-physical systems and the ability to analyze and respond to disturbances of such systems. She stressed the importance of research on how people perform under the stress of multiple disruptions.

Bethann Rooney emphasized the critical importance of relationships in being able to respond rapidly to a disruption and minimize its impact. Numerous port committees such as harbor operating committees are vital to being able to prepare, plan, respond to, and recover from all sorts of incidents.

CAPT Tucci highlighted the importance of exercises in preparing for incidents and mentioned the emergency plans developed with the help of Coast Guard Area Maritime Security Committees throughout the United States. He asked whether these plans are robust and if we are exercising them. And, most important, he wondered whether these plans cover situations where there are multiple disruptions at the same time.

CAPT Eric Johansson of the SUNY Maritime College talked about the impact of single and redundant points of failure, as well as increased weather events on ships operating in ports. Increasingly larger ships must rely a great deal on electronic navigation and escort tugs to offset the reduction of visual sight lines for pilots. Significant concerns he cited include cyberattacks, escort vessel vulnerabilities, episodic weather events, and the need for adequate safe anchorages.

CAPT Johansson said that an event is seldom unpredictable if correct organization and infrastructure is in place. We need to be prepared for unexpected but foreseeable events. To minimize the impacts of such events in a large port system, we need to develop risk analysis and recovery protocols for all stakeholders, prepare/review assets in key locations, prepare/review recovery facilities, and train individuals. He cited a resiliency report written by FEMA following Superstorm Sandy that highlights the role of the towing industry and its ability to shelter critical cargo at anchor in the Hudson River[3]. This is just one key feature of the industry that serves the Port of New York and the millions of citizens who rely on the maritime transportation system for critical cargo.

Fred Roberts, Director of the CCICADA COE, said that one can classify such incidents in terms of both spatial and temporal extent. Hurricanes and earthquakes are local and limited in time. This makes response easier and allows for use of other parts of a network. A pandemic like COVID was complicated because it was widespread geographically and also lasted a long time. He wondered what other disruptions might be of similar or greater scale.

Henry Willis of the Homeland Security Operational Analysis Center at RAND Corporation noted that climate change is another example of a widespread and lasting threat. These kinds of threats require totally different kinds of responses than the local and short-term disruptions.

CAPT Moskoff observed that the GPS system is critical to navigation but currently does not have a widely available alternative. He said that the Chinese and Russians, among others, can

[3] Regional Resilience Assessment Program. (November 2018). *New York City Critical Supply Chains Resilience Assessment*. p. 53, Office of Infrastructure Protection, Department of Homeland Security. *Note that the Office of Infrastructure Protection changed its name when the Cybersecurity and Infrastructure Security Agency (CISA) was created.*

manipulate it in ways to make it unusable, or worse, misleading in ways that could lead to a grounding, collision, or other marine casualty.

Casey Hehr of the Port of Long Beach noted that there is a pressing desire among terminal operators to electrify terminal operations. Operators cite environmental regulations in the State of California as well as the need to invest in infrastructure capable of handling increasingly large ships as key drivers. Given this trajectory, cyberattacks and the resilience of the electrical grid are of heightened concern and are major areas where research is needed.

Other concerns that were mentioned include dependence on automated systems to handle larger container ships, shifting the risk/impact from physical to cyber, and increasing urbanization, requiring technologies to handle traffic congestion near a port.

While specific mitigations might lower the probability of an impactful MTS incident or minimize the consequences of such an incident, there are some general approaches that might apply. CAPT Johansson suggested extensive study of probability of failure and consequences of failure for supply chains under different types of disruptions. The probability of failure is increasing due to more and more severe weather events, a reliance on technology leading to cyber/terrorist attacks, larger delivery modes making chokepoints more vulnerable, and the likelihood of pandemics increasing due to increased global movement of people.

8.6. A Bigger Picture: Beyond Ports and Vessels

Henry Willis introduced another way of looking at disruptions. He suggested that the global supply chain is not a single network. Instead there is a physical logistics layer, a transaction layer, and a governance layer, as illustrated in Figure 8. Natural disasters can affect the logistics layer, which includes ports, vessels, rail and truck carriers. Labor disruptions would affect this layer, as would piracy. Customer base disruptions such as decreasing or increasing demand would affect the transaction layer, which includes domestic and foreign suppliers, consolidators, and retailers. As an example, at the beginning of the pandemic, fuel consumption dropped. There were not enough places to store available fuel which led to some fuel being given away. Cyber events could also be in this layer or the logistics layer. Trade disputes, blockades, wars, etc. would affect the governance layer, which includes organizations such as the Coast Guard, Customs and Border Protection, the Federal Trade Commission, and the International Maritime Organization.

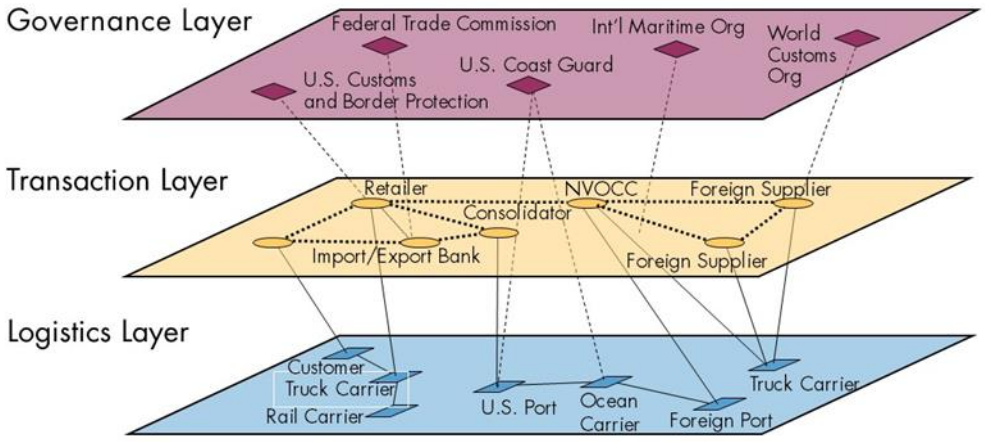


Figure 8: The supply chain has physical, transactional, and relational networks.
Courtesy of Henry Willis, Homeland Security Operational Analysis Center.
Source: Willis and Ortiz 2006 available at https://www.rand.org/pubs/technical_reports/TR214.html

While we heard from workshop speakers that the Suez Canal incident had relatively minimal and short-term impacts on particular US ports, we did not fully address the possibility that cascading impacts might have had large and longer-term economic and supply chain impacts. Most of the traffic through the Suez Canal coming from Asia is destined for Europe, not the US. What we need to investigate is whether delays in supplies headed to a port such as Rotterdam have downstream impacts in the US when those supplies are needed to produce goods that are later intended for the US. Research to understand the indirect effects of an event such as the Suez Canal blockage is needed.

The causes and impacts of disruptions cannot be limited to a single node or port, according to Gabriel Weaver of the University of Illinois at Urbana-Champaign. One needs to consider both upstream and downstream effects and system interconnections. A chokepoint in a connecting rail network might have a dramatic effect downstream on a seaport. In the future we will see co-located seaports and spaceports. Smart cities with smart traffic signals that get impacted could affect a nearby port. Autonomous technology in and around seaports could be a factor. Vulnerabilities in emerging communications technologies can impact trains and vessels, and ransomware is an increasing problem already.

Commenting on the vulnerabilities in emerging communications technologies, Fred Roberts said that while new technologies are needed to prevent or mitigate the impact of future disruptions, we have to keep in mind the possibility that new technologies might create new vulnerabilities that will make future disruptions more likely and/or increase their impact. For example, rapidly developing technologies are improving the efficiency of transportation systems, but also creating vulnerabilities and dependencies. Captain Tucci noted that while many automated systems can be operated manually, they cannot do so at the needed capacity for any sustained period.

9. Appendix: Speaker Bios

9.1. Workshop on Enhanced Supply Chain Crime During the Pandemic

9.1.1. Bios for the Panel on Crime in Licit & Illicit Supply Chains

Moderator: Jim Jones, Director CINA COE

Bio: Dr. Jim Jones is Associate Professor of Computer and Electrical Engineering at George Mason University and Director of the DHS Center of Excellence for Criminal Investigations and Network Analysis (CINA) led by George Mason University. Dr. Jones He has been a cybersecurity and digital forensics practitioner, researcher, and educator for over 25 years in industry, government, and academia. Past and current funded research sponsors include DARPA, IARPA, DHS, NSF, and DoD. Jim Jones has degrees in Systems Engineering (BS), Mathematical Sciences (MS), and Computational Sciences and Informatics (PhD).

Louise Shelley, George Mason University and CINA COE

Bio: Dr. Louise Shelley is the Omer L. and Nancy Hirst Endowed Chair and a University Professor at George Mason University. She is in the Schar School of Policy and Government and directs the Terrorism, Transnational Crime and Corruption Center (TraCCC) that she founded. She is a leading expert on the relationship among terrorism, organized crime and corruption as well as human trafficking, transnational crime and terrorism with a particular focus on the former Soviet Union. She also specializes in illicit financial flows and money laundering. She was an inaugural Andrew Carnegie Fellow. Her newest book written while on the Carnegie Corporation and Rockefeller Foundation Bellagio Fellowship, *Dark Commerce: How a New Illicit Economy is Threatening our Future*, on illicit trade, the new technology and sustainability was published with Princeton University Press in November 2018.

Kerry Bernstein, Principal Scientist, Modern Technology Solutions, Inc.

Bio: Kerry Bernstein is a consultant developing hardware security technologies for DoD. Formerly, he served for six years as a program manager in the Microsystems Technology Office at the Defense Advanced Research Projects Agency (DARPA). His interests are in the area of anti-counterfeiting, hardware security and emerging high performance post-CMOS device technologies. Mr. Bernstein formerly was a Senior Technical Staff Member at the IBM T.J. Watson Research Center, working for 33

years on high performance computing hardware. He attributes any successes realized to be due in large part to being surrounded by wonderful people throughout his entire career. Mr. Bernstein received his B.S. (1978) in Electrical Engineering from Washington University in St. Louis, and continued graduate work at the University of Vermont. He has co-authored four (4) textbooks, holds 155 patents, and is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE).

Randy Sandone, Executive Director, CIRI COE

Bio: Randall J. Sandone, a Certified Chief Information Security Officer, is the Executive Director of the Critical Infrastructure Resilience Institute (CIRI) which is a Department of Homeland Security, Center of Excellence. In this position Mr. Sandone is responsible for the operational, administrative, and financial management of the Institute. Mr. Sandone has had a comprehensive career guiding research and technology projects in settings ranging from start-ups to Fortune 100 companies. His strengths lie in strategy development, business development, and project management.

Mr. Sandone has over thirty years of experience in cyber security leadership. He has managed the development, testing, and certification of a variety of cyber security products used by customers ranging from the US Department of Defense, Intelligence Community, and other Federal agencies to private sector companies large and small around the world. In his current position at CIRI, Mr. Sandone has been instrumental in helping to guide a research, technology transition, and education and workforce development portfolio that is delivering impactful cybersecurity solutions to both the public and private sector. In this and in other executive leadership positions for a number of globally-oriented companies he was responsible for technology transition and licensing, commercialization, product development, and financial management.

Jere Miles, (Acting) Assistant Director, Operational Technology and Cyber Division, HSI

Bio: Jere Miles is the Assistant Director (AD), Operational Technology and Cyber Division, Homeland Security Investigations, Washington, DC. In his current assignment he exercises oversight of the enterprise wide Law Enforcement Technology; uses, R&D, purchasing and deployment, the global Cyber Investigations program; policy development, implementation and oversight as well as training of all cyber investigators and analysts dedicated to cyber forensics, intrusions or digital technology facilitated criminal activity. Additionally, he oversees HSI's enterprise wide investigative databases, big data project and global information sharing.

Prior to beginning his career as a Federal Criminal Investigator, SAC Mr. Miles served in the United States Army's 82nd Airborne Division, from 1984 until 1992, participating in Operation "Just Cause". After his honorable discharge, he served as a Deputy Sheriff in South Carolina

from 1993 – 1999, holding the positions of Patrol Deputy, Vice Detective and Resident Deputy Investigator.

He began his federal career in November 1999, with the U.S. Customs Service as an Air Enforcement Officer. In December 2000, he was converted to a Criminal Investigator and assigned to work in the U.S. Customs Service (USCS), Special Agent in Charge (SAC), Miami, FL. During his Federal career AD Miles has spent seven years overseas, Republic of Mexico, and held numerous leadership positions in both Homeland Security Investigations field offices and Headquarters.

9.1.2. Bios for the Panel on Rural Crime & Crime in Remote Areas

Moderator: General Randy "Church" Kee, Executive Director ADAC COE

Bio: Major General Randy "Church" Kee, United States Air Force (ret) is the Executive Director of the Arctic Domain Awareness Center (ADAC) at the University of Alaska, a DHS Center of Excellence. Since January 2016, General Kee leads a distributed team of Science and Technology, Research & Development. General Kee has led at the Squadron, Group, Wing and Air Ops Center levels. General Kee's staff assignments include U.S. Transportation Command, Headquarters USAF, and the U.S. Joint Staff in both Operations plus Strategic Plans and Policy Directorates. He has contributed to U.S. Arctic Strategy, supported domain awareness technology development, and Defense Support to Arctic crisis response. He culminated his military service as Director of Strategy, Policy, Planning and Capabilities for U.S. European Command in Stuttgart, Germany. General Kee is a Global Fellow at the Woodrow Wilson Center Polar Institute and serves an important role for the International Cooperative Exchange for Polar Research.

Shannon Jenkins, Senior Arctic Policy Advisor to the Commandant, HQ U.S. Coast Guard

Bio: Shannon Jenkins serves as head of the Arctic Policy Office at U.S. Coast Guard Headquarters. His responsibilities include coordinating Arctic cross-directorate actions, harmonizing Coast Guard program office and field efforts, leading Arctic policy and strategy development, and tracking Arctic implementation-plan actions and progress. Mr. Jenkins provides expert assistance on Arctic topics both internal and external to the Coast Guard and advances National interests and dialogue through public, private, and international forums. His mandate is to advance the Coast Guard's Arctic strategy of ensuring safe, secure, and environmentally responsible maritime activity in the region.

Prior to his role as Senior Arctic Policy Advisor, Mr. Jenkins served as a Program Manager within the Coast Guard's Research, Development, Test, & Evaluation Program. He managed the Arctic and the Environmental & Waterways research areas. His duties included identifying and prioritizing research needs, coordinating project execution and resource management, and

addressing internal and external leadership queries. Jenkins was also a member of the matrix team that developed the Coast Guard 2010 High Latitude Mission Analysis Report.

Shannon Jenkins has 30+ years of Federal service, most of those with the Coast Guard. He earned a BS degree in Mechanical Engineering from Mississippi State University and a Master's degree in National Resource Strategy from the National Defense University's Eisenhower School.

Whitney Lackenbauer, Trent University, Peterborough Ontario

Bio: Dr. Whitney Lackenbauer is Canada Research Chair in the Study of the Canadian North and a Professor in the School for the Study of Canada at Trent University, Ontario, Canada. He also serves as Honorary Lieutenant Colonel of 1st Canadian Ranger Patrol Group and is network lead of the North American and Arctic Defence and Security Network (NAADSN). He has (co-)written or (co-)edited more than fifty books and more than one hundred academic articles and book chapters. His recent books include *Breaking Through? Understanding Sovereignty and Security in the Circumpolar Arctic* (co-edited, 2021); *Canada and the Maritime Arctic: Boundaries, Shelves, and Waters* (co-authored 2020); *Custos Borealis: The Military in the Canadian North* (edited 2020); *Governing Complexity in the Arctic Region* (co-authored 2019); *Breaking the Ice Curtain? Russia, Canada, and Arctic Security in a Changing Circumpolar World* (co-edited 2019); and*China's Arctic Ambitions and What They Mean for Canada* (co-authored 2018).

Mike Duxbury, State of Alaska Deputy Commissioner for Public Safety (ret.)

Bio: Mike Duxbury is ADAC's Executive Counselor. Mr. Duxbury retired from the Alaska Department of Public (DPS) after serving 30+ years as an Alaska State Trooper in western Alaska and the Arctic regions. Mr. Duxbury promoted up the ranks with increased responsibility from first line supervisor to deputy commander. He also held statewide positions including Criminal Intelligence Unit supervisor, Statewide Drug Unit, and Alaska Bureau of Investigations Captain / commander. In 2019 Mr. Duxbury was appointment as the Deputy Commissioner of DPS. In 2020, he began working for a U.S. contractor providing analysis for a government client. Experiences such traveling 309 miles via snow-machine to visit assigned villages, village council meetings, Village Public Safety Officer training, and seeking collaborative solutions to public safety problems in Sub-Arctic and Arctic communities provides Mr. Duxbury with perspective on the intersect of public safety services enhancing state security, while informing national and regional arctic security. Mr. Duxbury has a BS in Criminal justice and is a graduate of the FBI NA Academy.

Jack Staton, DHS ICE, Deputy Director, Joint Task Force West

Bio: Agent Jack P. Staton assumed the duties of the Deputy Director, Joint Task Force – West (JTF-W), in December 2019. JTF-W is a component of the Department of Homeland Security's Southern Border and Approaches Campaign Plan.

Prior to his current assignment, Agent Staton served as the Special Agent in Charge for U.S. Immigration and Customs Enforcement Homeland Security Investigation's El Paso Office.

Staton also served in numerous field and headquarters leadership positions throughout his career including as the Executive Deputy Assistant Director for Homeland Security Investigation's Office of Intelligence and as the Deputy Assistant Director of the National Intellectual Property Rights Coordination Center.

Staton, a member of the Senior Executive Service with over 25 years of law enforcement, border security, emergency management and criminal intelligence experience, began his career as a Border Patrol Agent with the Immigration and Naturalization Service in 1995.

9.2. Workshop on the Supply of Labor During the Pandemic

9.2.1. Bios for the Panel on Workplace Safety

Moderator: Fred Roberts, Director CCICADA COE

Bio: Dr. Fred S. Roberts is a Distinguished Professor of Mathematics at Rutgers University and Director of the Command, Control, and Interoperability Center for Advanced Data Analysis (CCICADA), founded as a University Center of Excellence of DHS. He is Emeritus Director of DIMACS, one of the original National Science Foundation science and technology centers, with 14 academic and industrial partners and some 350 affiliated scientists. Among his current research interests are resilience of supply chains, challenges of disasters and pandemics, stadium and large venue security, resource allocation, maritime cyber security, and the homeland security aspects of global environmental change. Dr. Roberts has authored four books, edited 24 additional books, and authored 200 scientific articles, some translated into Russian and Chinese, included the first book on maritime cyber security. Among his awards are the Commemorative Medal of the Union of Czech Mathematicians and Physicists, the Distinguished Service Award of the Association of Computing Machinery Special Interest Group on Algorithms and Computation Theory, Fellow of the American Mathematical Society, the National Science Foundation Science and Technology Centers Pioneer Award, and an honorary doctorate from the University of Paris-Dauphine.

John Dony, National Safety Council

Bio: John Dony is the Director of the Campbell Institute, the global EHS&S center of excellence. In this role, Mr. Dony sets Institute strategy, oversees day-to-day operation of EHS&S initiatives and other key programs, and works closely with nearly 40 member organizations, partners, and others to share best practices and lessons learned around the world.

Since joining the National Safety Council in 2007, Mr. Dony has led numerous high-impact programs, including the prestigious Robert W. Campbell Award. John is a frequent speaker at conferences in North America and Europe on topics including EHS&S management systems, leadership, and leading indicators. Prior to joining the Council, John held quality management, project management, and coalition-building positions in the communication and educational fields.

Capt. Andrew Tucci, U.S. Coast Guard (ret.)

Bio: Capt. Andrew Tucci is a maritime risk consultant and retired U.S. Coast Guard Officer with 28 years of active duty service. He has experience and skills in Port Security, Port Safety, Homeland Security, Emergency Management, Marine Environmental Response, Cyber Security, Critical Infrastructure Protection, and related risk management fields.

Gina Ligon, Director, NCITE COE

Dr. Gina Scott Ligon is a Professor of Management and the Jack and Stephanie Koraleski Chair of Collaboration Science in the College of Business Administration at the University of Nebraska at Omaha (UNO). She is also the Director of the National Counterterrorism, Innovation, Technology, and Education (NCITE) Center for the Department of Homeland Security. She received her BS in psychology at Southwestern Oklahoma State University, and her PhD in Industrial and Organizational Psychology from the University of Oklahoma. Prior to joining UNO, she was a faculty member at Villanova University. Dr. Ligon has published over 80 peer-reviewed articles related to violent extremist organizations, leadership, and collaboration. Dr. Ligon also serves as the editor of one of the premier academic journals on terrorism, *Dynamics of Asymmetric Conflict: Pathways toward Terrorism and Genocide.*

William Spriggs, Howard University and Chief Economist, AFL-CIO

Bio: Dr. William Spriggs is a professor in, and former Chair of, the Department of Economics at Howard University and serves as Chief Economist to the AFL-CIO. In his role with the AFL-CIO he chairs the Economic Policy Working Group for the Trade Union Advisory Committee to the OECD, and serves on the board of the National Bureau of Economic Research. He is currently on the Advisory Board to the Minneapolis Federal Reserve Bank Opportunity & Inclusive Growth Institute. He served on the joint National Academy of Sciences and National Academy of Public Administration's Committee on the Fiscal Future for the United States; and with the National Academies of Sciences, Engineering and Medicine Committee on Closing the Equity Gap: Securing Our STEM Education and Workforce Readiness Infrastructure that produced the report: Minority Serving Institutions: America's Underutilized Resource for Strengthening America's STEM Workforce (2019).

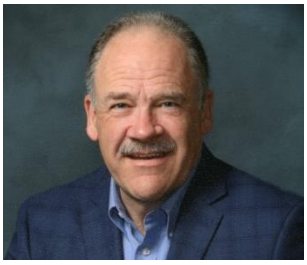
In 2014 he was a recipient of the NAACP Benjamin L. Hooks "Keeper of the Flame" Award, and in 2016 he received the National Academy of Social Insurance's Robert M. Ball Award for Outstanding Achievements in Social Insurance.

From 2009 to 2012, Dr. Spriggs served as Assistant Secretary for the Office of Policy at the U.S. Department of Labor. At the time of his appointment, he also served as chairman of the Healthcare Trust for UAW Retirees of the Ford Motor Company and as chairman of the UAW Retirees of the Dana Corporation Health and Welfare Trust, vice chair of the Congressional Black Caucus Political Education and Leadership Institute; and, as Senior Fellow of the Community Service Society of New York.

Spriggs has played a leading role in economic policy development serving: as Executive Director for the Institute for Opportunity and Equality of the National Urban League; with various federal agencies; and the Democratic staff of the Joint Economic Committee of Congress.

He graduated from Williams College, and holds a doctorate in economics from the University of Wisconsin-Madison. He has taught at North Carolina A & T State University (in Greensboro) and Norfolk State University (in Virginia).

Bill Richmond, Chief Operating Officer, National Security Directorate, Pacific Northwest National Laboratory



Bio: Bill Richmond currently serves as the Chief Operating Officer (COO) of the National Security Directorate (NSD) at Pacific Northwest National Laboratory and is responsible for the operations and budgets of the 1300+-staff directorate.

In this role, Mr. Richmond is responsible for smooth and efficient directorate operations, project execution, and capability development with a day-to-day focus on operational excellence and a long-term focus on aligning organizational capabilities with Directorate strategy and the needs of national security sponsors. Responsibilities include managing key metrics and performance indicators related to cost, project performance, and operational performance, including maintaining an integrated capability management plan. This plan drives NSD's recruiting of world-class staff

and provides an evaluation of the portfolio of work that simultaneously supports sponsors' missions while focusing on the advancement of science and technology.

Richmond joined Pacific Northwest National Laboratory in 1991, and since that time has been involved in developing and implementing many projects, ranging from waste form development and process systems design to tritium production and nuclear weapons disassembly.

Just prior to becoming COO, Mr. Richmond served as the Project Management Office (PMO) Director, where he was responsible for risk acceptance and management and supervised the execution of projects that supported DOE, NNSA, DOD, and DHS sponsors by conducting high-hazard nuclear or biological work at the laboratory. His project portfolio in the PMO ranged from fundamental research into chemicals and radioactive materials to intermediate-scale operations with radioactive materials to support signature discovery and pilot-scale operations to demonstrate processing technologies. Richmond was also responsible for development of a Biosafety Level 3 capability for the laboratory, to support sponsors in research in detecting and understanding the risk of biological agents.

Before his role as PMO Director, Richmond was the project manager and the Technology Integration Manager for the Pit Disassembly and Conversion Facility (PDCF) project. The PDCF project is a large ($50 million) commercial project for the design of a facility to process excess nuclear weapons pits into oxides for use in commercial reactor fuel. In addition to managing the project, he was responsible for direction of all technology development work. This included directing Los Alamos National Lab and Savannah River National Lab and commercial entities performing work for the project. Richmond began his career at PNNL as the Environmental Safety and Health Manager for the project.

Bill Richmond holds a Bachelor of Science in both Chemistry and Chemical Engineering from the State University of New York at Buffalo.

9.2.2. Bios for the Panel on Workforce Issues and Economic Costs

Moderator: Adam Rose, Director CREATE COE

Bio: Dr. Adam Rose is a Research Professor in the University of Southern California Sol Price School of Public Policy, Director of USC's Center for Risk and Economic Analysis of Terrorism Events (CREATE), Senior Research Fellow of the USC Schaeffer Center for Health Policy and Economics, and a Faculty Affiliate of the University of Illinois Critical Infrastructure Resilience Institute (CIRI). Professor Rose's primary research interest is the economics of terrorism and natural disasters. He has spearheaded the development of CREATE's comprehensive economic consequence analysis framework and has done pioneering theoretical and empirical research on resilience at the level of the individual business/household, market/industry and regional/national economy. He has also completed dozens of case studies of disaster consequences, resilience and recovery, including the September 11 terrorist attacks. He is the author of several books and 250 professional papers. He has received several honors and awards for his research including, the International Society for Integrated Disaster Risk Management Outstanding Research Award, Regional Economic Models, Inc. Excellence in Economic Analysis Award, and Applied

Technology Council Award for Outstanding Achievement. He is also an elected Fellow of the Regional Science Association International.

Tony Cheesebrough, Chief Economist, CISA

Bio: Tony Cheesebrough is Chief Economist for the Cybersecurity and Infrastructure Security Agency (CISA) at the U.S. Department of Homeland Security (DHS) and also an Adjunct Professor at Carnegie Mellon University. As Chief Economist for CISA, Mr. Cheesebrough leads a team of economists that apply benefit-cost analysis, economic impact analysis, modeling and simulation, risk analysis, and quantitative policy analysis to inform prioritization and resource allocation decisions for customers throughout DHS, the federal interagency community, state and local partners, and the White House. Tony previously served as Director for Risk and Capability Analytics in the DHS Office of Policy and Deputy Assistant Director for Risk Analytics in the DHS Office of Risk Management and Analysis. Cheesebrough is a member of the Society for Benefit Cost Analysis, the American Economic Association, the Economics of National Security Association, the Society for Risk Analysis, and the Institute for Operations Research and Management Science. He holds a Master's degree in Public Policy with a concentration in applied microeconomic analysis from Harvard University's Kennedy School of Government, as well as a B.A. in economics with the equivalent of a minor in mathematics from Swarthmore College.

Janet Kohlhase, University of Houston

Bio: Dr. Janet E. Kohlhase is a Professor of Economics at the University of Houston. She has a PhD from the University of Pennsylvania. Her research interests center on urban economics and regional science; most recently her works examine polycentric cities as well as labor force diversity and new firm formation and survival. Her work has been published in journals including the Review of Economics and Statistics, Journal of Urban Economics, Journal of Regional Science, Papers in Regional Science and Annals of Regional Science. She has long been active in the global associations of Regional Science, particularly the North American Regional Science Council (NARSC) and the Western Regional Science Association (WRSA). She was elected to be a Fellow of the Regional Science Association International in 2018. In addition to co-editing the Annals of Regional Science, she serves on the editorial boards for the Journal of Regional Science and Papers in Regional Science. Currently, she is president of the Western Regional Science Association and the Treasurer of the Urban Economics Association.

Richard John, CREATE COE

Bio: Dr. Richard S. John is Professor of Psychology and Associate Director at the Center for Risk and Economic Analysis of Terrorism Events (CREATE) at the University of Southern California. His research focuses on normative and descriptive models of human judgment and decision making and methodological issues in the application of decision analysis and probabilistic risk analysis (PRA). Dr. John has consulted on a number of large projects involving expert elicitation, including analysis of nuclear power plant risks (NUREG 1150) and analysis of cost and schedule risk for tritium supply alternatives. He has over 100 refereed publications, including top journals published by The Institute for Operations Research and Management Science (*INFORMS),* The Society for Risk Analysis (*SRA)* and the American Psychological Association (*APA*). Richard John received his PhD. in quantitative psychology from the University of Southern California in 1984, M.S. in applied mathematics from the University of Southern California in 1983, and B.S. in applied mathematics (summa cum laude) from the Georgia Institute of Technology in 1976.

Aaron Strong, RAND Corporation

Bio: Dr. Aaron Strong is an economist at the RAND Corporation. Recently, his work has centered around estimated the macroeconomic impact of a variety of different policies and programs including: NPI responses to COVID, hurricane recovery in Puerto Rico and U.S. Virgin Islands, land loss in Louisiana, changes to workers' compensation in California, Medicaid expansion, and changes to regulations for oil and gas refineries in California. In addition, Dr. Strong is interested in the role of systemic risk and resilience across the broad economy including development of a framework for estimating the value of resilience projects, a firm level model of the US economy, and valuing natural capital. Prior to joining RAND he held faculty positions at the University of Iowa and the University of Wyoming. He received his Ph.D. in economics from the University of Colorado and B.A. in math from Luther College.

9.3. Workshop on the Food Supply Chain During the Pandemic

9.3.1. Bios for the Panel on Hunger Relief

Moderator: Lauren Davis, Professor of Industrial & Systems Engineering, North Carolina A&T University

Bio: Dr. Lauren Davis is Professor of Industrial & Systems Engineering, North Carolina A&T University. Her research explores supply chain optimization—especially food supply chains—humanitarian logistics, and emergency preparedness and response. She holds a B.S. in Computational Mathematics from Rochester Institute of Technology, and M.S. in Industrial & Management Engineering from Rensselaer Polytechnic Institute, and a Ph.D. in Industrial Engineering from North Carolina State University.

Blake Thompson, Feeding America Food Bank

Bio: Blake Thompson is responsible for leading Feeding America's strategic work to increase the amount of nutritious food available through the network for people facing hunger. Blake joined Feeding America in September of 2018.

Mr. Thompson has built a long career in the food industry and has extensive end-to-end supply chain experience. He has had responsibility for every function of the supply chain. He comes to Feeding America from Swisher Hygiene, where he served as SVP & Chief Operating Officer where he was tasked with integrating over 163 acquisitions into a single supply chain and national service organization.

Previously, Thompson served as Chief Supply Chain Officer at Tasty Baking, Co., where he led the planning and re-engineering of the company's branded product manufacturing platform as well as the DSD operations. He also served as Senior Vice President, Supply Chain at Snyder's-Lance, Inc., which was purchased in 2018 by The Campbell's Soup Company.

During his 23 years at Frito-Lay, Mr. Thompson developed experience across all aspects of supply chain and manufacturing operations. He was also heavily engaged in the cultural transformation process, driving change leadership excellence and continuous improvement programs.

Blake Thompson holds a Bachelor of General Studies Degree in Economics and Political Science from the University of Kansas.

Katie Nye, Baylor Collaborative on Hunger and Poverty, Baylor University

Bio: Katie Nye has over 10 years of experience in nonprofit management with a background in social work. Since 2013 she has served the Texas Hunger Initiative. She currently supervises all seven Texas field offices as Statewide Field Director, as well as coordinating the strategy for reducing child hunger. She received a Master of Science in Social Work from The University of Texas at Austin in 2009 with a concentration in Community and Administrative Leadership.

Kevin King, Deputy Commissioner of Agriculture, New York State Department of Agriculture and Markets

Bio: Kevin S. King developed an early passion and interest in farming and forestry growing up in the farm fields of Western New York. His formal education is in resource management and forest biology and included stops in the Catskills, Central New York, Adirondacks and ultimately the Capital District, where he has lived and worked for the last thirty years.

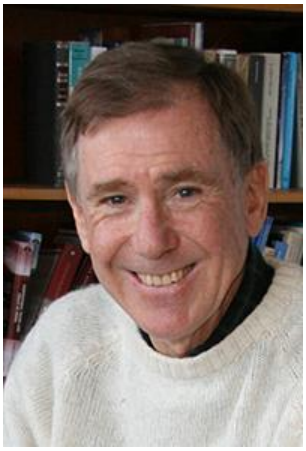
Mr. King is currently serving as Deputy Commissioner at the NYS Department of Agriculture and Markets. His responsibilities include oversight and strategic direction for agricultural development programming, weights and measures inspection, metrology services, food systems policy, and farm labor issues.

Mr. King joined the Department in 2010 as Director of the Department's Division of Plant Industry. He was asked to reorganize the Division of Agricultural Development in 2013 and served as its Director until his recent appointment to Deputy Commissioner. Prior to that he was Executive Director for the statewide trade association representing forestry and forest products manufacturers in New York.

In his current capacity, Mr. King has had the privilege to play a key role in the design and implementation of several noteworthy and successful initiatives advanced by New York Governor Andrew Cuomo, including Taste NY, NYS Grown & Certified, and Nourish NY.

9.3.2. Bios for the Panel on Food Supply Chain Vulnerabilities

Moderator: Dan Sumner, Frank H. Buck, Jr. Distinguished Professor of Agricultural and Resource Economics, University of California, Davis



Bio: Dr. Dan Sumner is the Frank H. Buck, Jr. Distinguished Professor in the Department of Agricultural and Resource Economics at the University of California, Davis and the Director of the University of California Agricultural Issues Center. Sumner teaches the Economics of Agricultural Sustainability and directs an extensive outreach and applied research program on public issues related to agriculture. He has published broadly in academic journals, books, and industry outlets. His research and writing has received numerous awards for research quality, quality of communication and contribution to policy. He has served as Chair of the International Agricultural Trade Research Consortium, a consultant for farm organizations, government agencies and companies and is a frequent speaker at national and international conferences and symposia. In 1998, he was named a fellow of the American Agricultural Economics Association for his career achievements.

From 1978 to 1992, he was a professor at North Carolina State University. He spent much of the period after 1986 on leave for government service in Washington, DC, where he was at the President's Council of Economic Advisers and the U.S. Department of Agriculture (USDA).

Immediately prior to moving to California in January 1993, Sumner was the Assistant Secretary for Economics at the USDA, where he contributed to policy formulation and analysis on the whole range of topics facing agriculture and rural America — from food and farm programs to trade, resources, and rural development. As supervisor of the USDA's economics and statistics agencies, he also was also responsible for USDA data collection, outlook and economic research.

Dan was raised on a fruit farm in Suisun Valley, California where he was active in 4-H and FFA. He received a bachelor's degree in agricultural management from California Polytechnic State University in San Luis Obispo in 1971, a master's degree from Michigan State in 1973, a PhD in economics from the University of Chicago in 1978 and did his Post-doc at RAND.

Michelle M. Colby, Chief, National Security Division, Office of Homeland Security, USDA

Bio: Dr. Michelle M. Colby, DVM, is currently serving as the Chief of the National Security Division in USDA's Office of Homeland Security where she provides guidance and direction for national security programs related to homeland security, agroterrorism, biodefense, disaster response and recovery, and efforts to coordinate national-level homeland security policy initiatives. She also serves as the USDA co-chair of the Food and Agriculture Sector Government Coordinating Council.

From 2017-2019 Dr. Colby served as the National Program Leader for Animal Biosecurity in the Division of Animal Systems at the National Institute of Food and Agriculture (NIFA). Prior to joining NIFA, Dr. Colby served as the Branch Chief for Agricultural Defense in the Chemical and Biological Defense Division (CBD) of DHS's Science and Technology Directorate where she directed all of CBD's research and development efforts related to agricultural defense. Before joining DHS in 2009, she served as the Assistant Director for Chemical, Biological, Radiological and Nuclear Countermeasures in the Homeland and National Security

Division of the White House Office of Science and Technology Policy (OSTP) where she managed all of OSTP's work on coordinating research and development on countermeasures to chemical, biological, radiological and nuclear threats.

Dr. Colby completed a post-doctoral research fellowship at the Maryland campus of the Virginia-Maryland Regional College of Veterinary Medicine (VRMCVM), as well as a M.S. in Epidemiology and three-year applied veterinary epidemiology residency program. Dr. Colby received her Doctorate of Veterinary Medicine from VRMCVM and a B.S. degree in Animal Science from the University of Maryland, Eastern Shore.

LeeAnne Jackson, Food and Drug Administration

Bio: Dr. LeeAnne Jackson earned her Bachelor of Science, Master's, and Ph.D. from the University of Kentucky. She completed a post-doctoral assignment with the U.S. Department of Agriculture's Agriculture Research Service in Wyndmoor, PA and subsequently joined the Food and Drug Administration's Center for Food Safety and Applied Nutrition (FDA/CFSAN) in 1991 in a laboratory position. She has held a variety of policy positions within FDA/CFSAN. To ensure the defense of the nation's food supply, she serves on a variety of government working groups to discuss food defense activities. She was instrumental in the formation of the Food and Agriculture Sector and currently serves as the FDA Co-Chair for the Food and Agriculture Sector Government Coordinating Council. Most recently, she serves as the CFSAN Food Lead for FDA's COVID-19 Incident Management Group.

Jeremy Jackson, Anneal Initiative, Inc.

Bio: Jeremy Jackson is a founder of Anneal Initiative, Inc, an analysis and strategic planning business. Previously, Mr. Jackson was the Director of the Kansas Intelligence Fusion Center (KIFC), where he stood up and led the KIFC's unique integration of cyber and biological threat experts from industry, government, and academia into intelligence analysis operations. Prior to directing the KIFC, Jackson designed and developed homeland security capabilities for Kansas, including the Kansas Intelligence Fusion Center.

Mr. Jackson also serves in the Kansas Air National Guard at the 184th Wing Headquarters. He previously performed strategic analysis and planning regarding intelligence and cyber capabilities for the Kansas Adjutant General and Kansas Joint Forces Headquarters. His military experience also includes development of cyber threat intelligence and vulnerability assessments, as well as supervising analysts providing intelligence support to deployed forces. He previously served in the Army Reserve and the Army National Guard.

Mr. Jackson has nearly 10 years of private sector engineering and project management experience, focusing primarily on electronic building systems and industrial controls for the

power industry. Jeremy Jackson graduated with a Bachelor of Science in Mechanical Engineering in 1996 from Kansas State University and graduated with a Master of Arts in Intelligence Studies from American Military University in 2013.

Col. John Hoffman, Senior Research Fellow, Food Protection & Defense Institute (COE), University of Minnesota

Bio: Col. John Hoffman joined the National Center for Food Protection and Defense, later the Food Protection and Defense Institute, at the University of Minnesota as a Senior Research Fellow in 2007. In this capacity he has worked with government and industry to document and assess vulnerabilities within the national food and agriculture sector, identify effective mitigation steps, and build resilience into these critical national supply chains to assist in the implementation of our national health security. Previously, he served as the first Food and Agriculture Infrastructure Program Manager within the new U.S. Department of Homeland Security, Infrastructure Protection Directorate from 2003 to 2005, following a thirty-year military career.

Will Martin, Senior Research Fellow, International Food Policy Research Institute (IFPRI)

Bio: Dr. Will Martin is an IFPRI Senior Research Fellow and immediate Past President of the International Association of Agricultural Economists. In the early 2000s he led a large research project with the Development Research Center of State Council on economic impacts of China's WTO accession. His recent research has focused on the impacts of changes in trade policies and food prices on poverty and food security in developing countries; and impacts of productivity growth on poverty. He was the World Bank's research manager for agricultural and rural development before joining IFPRI in 2015.

9.4. Workshop on Supply Chains for Medicines, Vaccines, PPEs During the Pandemic

9.4.1. Bios for the Panel on Vaccines

Moderator: CCICADA Director Fred Roberts moderated this panel. His bio is provided in Section 9.2.1.

Joe Lewis, Managing Director, Deloitte Consulting

Bio: Joe Lewis has nearly 20 years of consulting experience focused on supply chain, global business transformation, and business process improvement. For the last eleven years, Mr. Lewis has been focused on the life sciences sector, and has delivered digital and analytics-led supply chain transformations, as well as integrated business planning, supply chain risk, and network optimization projects for pharmaceutical manufacturers. In his current role, he oversees Deloitte Consulting's supply chain and manufacturing activities for two top pharma manufacturers and is currently leading Deloitte's US Life Sciences Supply Chain COVID response programs. Joe Lewis holds a BE in Naval Architecture from SUNY Maritime College and an MBA from UNC's Kenan-Flagler Business School

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Karin Shanahan, SVP of Global Biologics & Sterile Operations, Merck

Bio: Karin Shanahan has nearly 25 years of experience in the pharmaceutical industry, beginning her pharma career with Bristol-Myers Squibb in their global supply chain organization. Working with a cross-functional team, Ms. Shanahan helped Bristol-Myers Squibb design the Product Development & Commercialization process; later leading the launch readiness for the Abilify launch. She moved into manufacturing operations to lead two manufacturing operations, first a radio-pharmaceutical operation in Billerica, MA and then the networks' largest API and DP site in Latina, Italy. She left BMS to join Becton Dickenson as VP, Global Operations supporting their Pre-Analytical Services business unit. After a brief role with Catalent Pharmaceuticals, she moved to Teva Pharmaceutical as SVP, Americas & EU Sterile Operations where she had responsibility for 24 sites in Canada, US, Latin America and Europe. During her 5 years at Teva, Shanahan created the MS&T (Manufacturing, Science & Technology) organization to enhance product launch capabilities, took on responsibility for network strategy and was globally responsible for Operational Excellence. She recently joined Merck as SVP, Global Biologics and Sterile Operations where she has operational responsibility for Keytruda and an IO pipeline of products. In this role, she is also accountable to supply several vaccines, most notably Gardasil. Prior to joining the pharma industry, she held supply chain roles at Daimler Benz and the U.S. military in her hometown of Berlin, Germany. She holds a BA in Political Science & International Relations from Rutgers University and is earning her MSJ in Pharmaceutical and Device Law at Seton Hall University.

Bill McLaury, Rutgers School of Business (retired from Novartis)

Bio: William (Bill) McLaury was the Executive Director, Pharma Supply Chain with Novartis Pharmaceuticals for over thirty years before retiring in July 2014 and joining the Rutgers Business School (RBS) faculty full time. While with Novartis, Mr. McLaury held a number of supply chain management leadership positions with operational responsibility, both locally and globally, including ten years as Regional Head for North America, and two years as Global Head of Pharma Supply Chain Strategy. He also served as the Novartis representative on the Industry Advisory Board for the Center for Supply Chain Management at RBS for fourteen years, and as the Chairman of that Advisory Board for the last five.

McLaury is the creator of the Rutgers SCM Curriculum for Secondary Schools which has been adopted by the New Jersey Department of Education, and used in individual schools in 6 other states as well. He is also the author of the textbook, "*Fundamentals of Supply Chain Management, A Practitioner's Perspective*" which is used both in the Introduction to Supply Chain Management course at RBS as well as for the Rutgers SCM Curriculum for Secondary Schools.

McLaury is a member of the American Production and Inventory Control Society (APICS), the Institute for Supply Management (ISM), and the Council of Supply Chain Management Professionals (CSCMP) where he served as the Education Chair for the NJ Roundtable. He continues to be a frequent guest speaker at numerous industry and academic events.

Bill McLaury has a Bachelor of Science degree in Supply Chain Management from Bowling Green State University, a Masters Certificate in Project Management from George Washington University, and a Master of Administrative Sciences degree from Fairleigh Dickinson University.

Juergen Richt, Director CEEZAD COE

Bio: Dr. Juergen A. Richt, DVM, came to Kansas State University in 2008 as The Regents Distinguished Professor and Kansas Bioscience Eminent Scholar. In 2010, he became Director of the Department of Homeland Security (DHS) *Center of Excellence for Emerging and Zoonotic Animal Diseases* (CEEZAD) and in 2020 Director of the National Institutes of Health (NIH) *Center on Emerging and Zoonotic Infectious Diseases* (CEZID). He received his Doctorate in Veterinary Medicine (DVM) from the University of Munich and a PhD in Virology and Immunology from the University of Giessen, both in Germany. After coming to the United States in 1989, he completed three years of postdoctoral/residency studies at The Johns Hopkins University and later served for eight years as a Veterinary Medical Officer at the National Animal Disease Center (USDA-ARS) in Ames, Iowa. He has edited several books, published more than 250 peer-reviewed manuscripts and raised more than $50 million in grants for veterinary research.

Dr. Richt is a pioneer in veterinary science, most notably in the "*One Health*" field. His work on high consequence pathogens with zoonotic and transboundary potential led to strategies to identify, control and/or eradicate such agents. His basic and applied research includes studies on animal influenza viruses, animal prion diseases including bovine spongiform encephalopathy (BSE), Rift Valley Fever virus (RVFV), African Swine fever virus (ASFV) and Borna Disease virus (BDV). Dr. Richt established the first reverse genetics system for swine influenza virus (SIV), and made seminal contributions to the development of a modified live SIV vaccine now sold in the U.S. as "Ingelvac Provenza™" and to understanding the virulence of the reconstructed 1918 "Spanish Flu" virus in livestock. He identified an atypical BSE case with a causative mutation ("genetic BSE"), used gene-editing approaches to develop the first prion protein knock-out cattle which are resistant to prion infection, and provided valuable information on host range of animal prions essential for risk analysis. Dr. Richt's RVFV work led to the development of novel domestic and wild ruminant models for RVF and a safe, efficacious, and DIVA compatible subunit vaccine which is presently undergoing USDA licensure. For ASFV, he is developing subunit and modified live virus vaccine candidates as well as Point-of- Need diagnostics (PenCheck™) to protect swine from this devastating disease. His recent work focused on the establishment of preclinical animal models for COVID-19 in cats, hamsters and ferrets. As founding Director of the DHS CEEZAD and the NIH CEZID Centers, he is supporting NIH, DHS and USDA in protecting public health and U.S. agricultural systems from devastating animal and zoonotic diseases.

9.4.2. Bios for the Panel on Supply Chains for Medicines and PPE

Moderator: Dennis Egan, Assistant Director CCICADA COE

Bio: Dr. Dennis Egan is a Research Professor at Rutgers University and was appointed Assistant Director of CCICADA in 2015. Prior to his appointment at Rutgers, he had a thirty-six-year career as a researcher and research manager at Bell Laboratories and its successor companies Bellcore, Telcordia, and Applied Communication Sciences. He retired in 2013 as Executive Director, Information Analysis and Services Research.

Since joining CCICADA, Dr. Egan has led projects applying data science to problems of enterprise and homeland security. He is currently PI on a DHS S&T project focused on training and certification requirements in cyber forensics for DHS and State and Local law enforcement agencies. He has co-authored recent reports on large venue security for the DHS Office of SAFETY Act Implementation, on cyber security education for the DHS S&T Cyber Security Division, and on cyber security information sharing for the U.S. Coast Guard. Egna currently represents CCICADA on the Cyber Security Subcommittee for the USCG Port of New York and New Jersey Area Maritime Security Committee (AMSC). Dennis Egan received his M.A. in Applied Mathematics and Ph.D. in Experimental Psychology from the University of Michigan.

Eric Garvin, Head of Pharma Solutions, Chronicled, Lead of MediLedger Network

Bio: Eric Garvin is the lead of the MediLedger Project, co-founder of The LinkLab, and a Pharma industry consultant with more than twenty-five years of management and project management experience in the Life Sciences industry. Mr. Garvin has focused on business development, M&A, Supply Chain, and IT projects. He has spent the last 6 years leading serialization implementation programs, both for the US and globally, and driving the development of blockchain-based solutions with the mission of establishing the first Pharma blockchain network. Eric Garvin earned his B.S. from the University of Notre Dame.

Rory Yanchek, VP Government Markets, 3M

Bio: Rory Yanchek is the Vice President and General Manager of 3M Government Markets. In this role he is responsible for the strategic and operational leadership of 3M's United States Government focused business.

Previously, He was the Vice President and General Manager of 3M's Aerospace and Commercial Transportation Division. His team designed, manufactured and marketed an innovative portfolio of engineered material science solutions for the aerospace and commercial transportation industries. From 2012 to 2014 he was the Vice President and General Manager of 3M Defense Markets Division. This cross-3M division organization was chartered to bring 3M's broad technology capabilities and product solutions to the global defense industry. Mr. Yanchek led 3M's Track and Trace Solutions Division as General Manager from 2008 to 2012. Prior to the Track and Trace assignment, Yanchek was responsible for Government sales and marketing for 3M's Occupational Health business. He was the key architect behind the successful development and successful launch of the world's first powered air purifying respirator used for the protection of First Responders.

Before joining 3M, Yanchek served in leadership positions with international health care and medical device companies. At Racal Health & Safety Inc., he was Director of Government Sales and Marketing responsible for respiratory protection devices and before that, he spent a decade with Schein Pharmaceutical and Allergan Pharmaceuticals in various U.S. and global sales, sales management and marketing management roles.

Rory Yanchek holds a Master of Business Administration from The University of St Thomas (Minnesota) and a Bachelor of Arts in Political Science from East Stroudsburg University (Pennsylvania). He served over ten years in the active and reserve components of the United State Army as an Airborne Ranger Qualified Infantry Officer.

He is active in business, professional and civic organizations including Board membership of the Alliance to Save Energy, membership in the Business Executives for National Security (BENS), past Chairman of the Board of Aearo Technologies, LLC, and Board of Governors member of the Aerospace Industries Association.

Viswanath Narayan, Rutgers School of Business (retired from Pfizer)

Bio: Viswanath Narayan is a part-time lecturer who brings more than 30 years of experience to bear when teaching in the Master of Supply Chain Analytics program at Rutgers Business School. He retired from Pfizer where he was director of supply chain analytics business technology. He is an experienced professional with Automotive and Pharmaceutical experience with data analytics and supply chain. Mr. Narayan has an undergraduate degree from Birla Institute of Technology and an MS in Industrial Engineering from Arizona State University and an MS in BIA from Stevens Institute of Technology.

Daniel Gerstein, RAND Corporation, Homeland Security Operational Analysis Center

Bio: Dr. Daniel M. Gerstein is a senior policy researcher at the RAND Corporation. Previously, he served at the U.S. Department of Homeland Security (DHS) as Under Secretary (Acting) and Deputy Under Secretary in the Science & Technology Directorate. He has extensive experience in security and defense while serving as a Senior Executive Service (SES) government civilian, in uniform, and in industry. He is also an adjunct professor at American University in Washington, D.C. In DHS S&T, he managed the directorate's $1-billion budget and spearheaded several cross-departmental efforts in big data, cybersecurity, and biodefense. Dr. Gerstein began his professional career in the U.S. Army, serving on four continents, participating in combat, peacekeeping, humanitarian assistance, counterterrorism, and homeland security. Following retirement from active duty, he joined L-3 Corporation as Vice President for Homeland Security Services. Before joining DHS, Gerstein was the Principal Director for Countering WMD in OSD (Policy). He also served on the Holbrooke Delegation that negotiated the peace settlement in Bosnia, established SOUTHCOM's cybersecurity facility following 9/11, developed a biosurveillance system for DoD, and led the Army's most comprehensive restructuring since WWII. He has been awarded many foreign, military, and civilian awards, including the U.S. Army Soldiers Medal for heroism. He has published many books and articles on national security topics and is a member of the Council on Foreign Relations. Gerstein graduated from West Point and has Master's degrees from Georgia Tech, National Defense University, and Army Command & General Staff College, and a Ph.D. from George Mason University.

Brian Weinhaus, ICE-HSI, Operation Stolen Promise

Bio: Brian Weinhaus is a Unit Chief with the Homeland Security Investigations (HSI) led Intellectual Property Rights Coordination Center (IPRC). Mr. Weinhaus has 25 years of law enforcement experience with four law enforcement agencies. He arrived at the IPRC in February 2020 from his most recent tour as a group supervisor for the HSI Detroit field office. Weinhaus now oversees all the national intellectual property (IP) investigative operations which concentrate on

sectors such as automotive, pharmaceuticals, health and beauty products, consumer electronics, clothing and sports merchandise, tobacco, and government and DOD supply chain security.

9.5. Workshop on COVID-19 Vaccines: Efficacy & Safety

CEEZAD Director Juergen Richt moderated this workshop. His bio is provided in Section 9.4.1.

Keynote Speaker: **Florian Krammer**, Professor of Vaccinology, Mt. Sinai School of Medicine

Bio: Dr. Florian Krammer, graduated from the University of Natural Resources and Life Sciences, Vienna (Austria) in 2010. He received his postdoctoral training in the laboratory of Dr. Peter Palese at the Icahn School of Medicine at Mount Sinai, New York working on hemagglutinin stalk-based immunity and universal influenza virus vaccines. In 2014 he became an independent principal investigator and is currently Mount Sinai Professor of Vaccinology at the Icahn School of Medicine at Mount Sinai. Dr. Krammer's work focuses on understanding the mechanisms of interactions between antibodies and viral surface glycoproteins and on translating this work into novel, broadly protective vaccines and therapeutics. The main target is influenza virus but he is also working on coronaviruses, flaviviruses, hantaviruses, filoviruses and arenaviruses.

9.5.1. Bios of the Panelists

Fred Cassels, PATH Center for Vaccine Innovation and Access

Bio: Dr. Fred Cassels leads the Enteric and Diarrheal Diseases (EDD) division (since 2016), which focuses on rotavirus, polio, *Shigella*, and enterotoxigenic *E. coli* (ETEC) vaccines, while also heading up the COVID-19 Initiative Team, all within the Center for Vaccine Innovation and Access (CVIA) at PATH. EDD/CVIA projects range from vaccine discovery, generation of *in vitro* and *in vivo* proof of concept, cGMP manufacture, phase 1-4 clinical trials, licensure in country and through the WHO, and includes country introduction of vaccines, for the benefit of low and middle income countries. Dr. Cassels previously served in the role of Chief of the Enteric and Hepatic Diseases Branch (2011-2016), Division of Microbiology and Infectious Diseases (DMID), National Institute of Allergy and Infectious Diseases, National Institutes of Health. The work there encompassed the management of grants, preclinical product development and vaccine manufacturing contracts, as well as domestic and international clinical trials. Also while at DMID, he served as the Severe Acute Respiratory Syndrome (SARS) and Influenza Vaccines Program Officer (2004-2011). Prior to DMID, Dr. Cassels worked in the Department of Enteric Infections, Walter Reed Army Institute of Research (1988-2004), developing ETEC vaccine candidates and delivery technologies, and testing them preclinically and in Phase 1 human trials.

Philip Dormitzer, Vice President and Chief Scientific Officer Viral Vaccines, Pfizer

Bio: Dr. Philip Dormitzer leads Pfizer viral vaccines research and development programs. These programs include the Pfizer-BioNTech RNA-based COVID-19 pandemic vaccine and influenza vaccine collaborations. The COVID-19 vaccine has been authorized for emergency use, and mass vaccination campaigns have begun. A prefusion F-based RSV vaccine to protect infants through maternal immunization has been advanced from discovery to a global phase 3 clinical trial in pregnant women. A cytomegalovirus vaccine candidate is preclinical. Before joining Pfizer, Dr. Dormitzer held positions at Novartis Vaccines that included Head of US Research. He was the founding member of the Novartis Viral Vaccine Research Center in Cambridge, MA. In 2009, his research team supported the development and licensure of three H1N1v influenza pandemic vaccines in the most rapid vaccine response in history, prior to the current COVID-19 pandemic. In 2013, his team responded to the H7N9 influenza outbreak by supplying the US pre-pandemic stockpile with a vaccine generated from a synthesized virus. Before joining industry, Dr. Dormitzer was an Assistant Professor of Pediatrics at Harvard Medical School and led a structural virology laboratory, which, with collaborators, determined the structures of the rotavirus neutralization antigens. He graduated summa cum laude in Anthropology from Harvard College; conducted paleontological research in Pakistan and studied the Efe Pygmies in Zaire; obtained a Ph.D. in Cancer Biology and an MD at Stanford University; completed Internal Medicine training at Massachusetts General Hospital; and completed the Harvard Infectious Diseases Program clinical fellowship.

Adolfo Garcia-Sastre, Mt Sinai School of Medicine

Bio: Dr. Adolfo Garcia-Sastre is Professor in the Departments of Microbiology and Medicine and in the Tisch Cancer Center at Icahn School of Medicine Mount Sinai (ISMMS) in New York. He is also Director of the Global Health and Emerging Pathogens Institute at ISMMS, and Principal Investigator for the Center for Research on Influenza Pathogenesis (CRIP), one of five NIAID Centers of Excellence for Influenza Research and Surveillance (CEIRS). For the past 30 years, his research interest has been focused on the molecular biology, virus-host interactions, innate immunity and pathogenesis of influenza viruses and several other RNA viruses, as well as on the development of new vaccines and antivirals. He has more than 500 peer-reviewed publications in these areas of research. He has been President of the International Society for Vaccines in 2014-2015. He is Editor for the scientific journals PLoS Pathogens, Journal of Virology and Virus Research. In 2017, he was elected as a fellow of the Royal Academy of Pharmacy in Spain. In 2019, he was recognized with an Honorary Doctor Degree from the University of Burgos, Spain. Also in 2019, he was elected a member of the National Academy of Sciences and of the National Academy of Inventors.

Hana Golding, Center for Biologics Evaluation and Research, FDA

Bio: Dr. Hana Golding is the Chief of the Laboratory of Retrovirus at the Division of Viral Products, Center for Biologics Evaluation and Research (CBER), FDA. Dr. Golding received her Ph.D. degree from Oregon Health Sciences University, Oregon, and her postdoctoral training at the Experimental Immunology Branch, NCI, NIH. Dr. Golding joined the Division of Viral Products, CBER in 1987 and was assigned as the Chief of the Laboratory of Retrovirus Research in 1993. Dr. Golding has authored more than 200 research papers and book chapters on immunology, virology, and infectious diseases topics.

- The main areas of research projects in the Golding lab:
  Vaccines against viral pathogens including pandemic Influenza, RSV, Ebola, Zika, HIV, and SARS-CoV-2;
- Evaluation of vaccine safety (in vivo/in vitro) and immune responses, including new methods for antibody avidity and epitope diversity; and
- Vaccine Adjuvants: their mode of action, impact on immune responses, and new biomarkers predictive of their safety and efficacy in humans.

Randall N. Hyer, Senior Vice President, Global Medical Affairs, Moderna

Bio: Dr. Randy Hyer has over three decades of experience in medicine and public health in both the public and private sectors. After graduating with distinction from the US Naval Academy, he studied at Duke Medical School and then earned the PhD in molecular biology from Oxford University. He then spent 13 months on the "ice" in Antarctica as the Station Physician for the winter. Dr. Hyer then shifted to public health and vaccines, serving four years at the World Health Organization as a medical officer responding to outbreaks and emergencies including anthrax, Ebola, SARS, avian influenza, as well as tsunamis and earthquakes. In response to the need for effective communication, Dr. Hyer co-authored a popular WHO handbook on risk and crisis communication during public health emergencies. In industry, Hyer's experience covers vaccines, biologics, biosimilars, and small molecule development. He was pivotal to the 2017 approval of a two-dose adult hepatitis B vaccine (HEPLISAV-B), the first FDA approved vaccine with a truly novel adjuvant. Beyond development, his responsibilities have included directing vaccine and pharmaceutical safety programs, overseeing vaccine clinical operations and biometrics functions, engaging medical scientists and policy-makers, and managing crises. His perspectives and contributions span his residing in eight and traveling to 100 plus countries in diverse roles across the public and private sectors.

Karen Makar, Bill & Melinda Gates Foundation

Bio: Dr. Karen Makar is a PhD immunologist with expertise in molecular epidemiology, clinical immune monitoring and biomarker discovery. As a Senior Program Officer on the Vaccine Discovery & Human Immunobiology team at the Bill & Melinda Gates Foundation, she leads an immune correlates initiative which identifies and prioritizes immune correlates activities for the foundation's invested vaccines to accelerate the discovery, development, and licensure of effective vaccines for BMGF target populations in low and middle income countries. In 2014, she launched the Global Health – Vaccine Accelerator Platforms (GH-VAP) program to connect foundation grantees with high quality, cutting edge research platforms. GH-VAP has grown to over 200 projects across 14 platforms serving more than a dozen different disease areas. Previously, she served as Director of the Molecular Epidemiology Laboratory at Fred Hutchinson Cancer Research Center and worked in industry as a Vaccine Development Scientist evaluating therapeutic cancer vaccines.

Stanley Perlman, The University of Iowa, Professor of Microbiology and Immunology, and of Pediatrics

Bio: Dr. Stanley Perlman received his Ph.D. in Biophysics from MIT and his M.D. from the University of Miami. He was trained in Pediatrics and Pediatric Infectious Diseases at Boston Children's Hospital. His current research efforts are focused on coronavirus pathogenesis, including virus-induced demyelination and the Severe Acute Respiratory Syndrome (SARS), the Middle East Respiratory Syndrome (MERS) and COVID-19.

His laboratory has developed several novel animal models useful for studying pathogenesis and evaluating vaccines and anti-viral therapies. His studies are directed at understanding why aged patients and mice developed more severe disease than younger individuals after infection with SARS-CoV or SARS-CoV-2 and also on why there is a male predominance in patients with more severe disease after infection with SARS-CoV, MERS-CoV or SARS-CoV-2. He and his colleagues demonstrated that transduction of mice with an adenovirus expressing the human receptor for MERS-CoV, DPP4, rendered them sensitive to infection, providing the first rodent model useful for studying MERS. Similar approaches have been used to develop a mouse model for COVID-19. He has also developed models for the loss of sense of smell (anosmia) observed in patients with COVID-19.

9.6. Workshop on COVID-19 Vaccines: Distribution & Prioritization

CCICADA Director Fred Roberts moderated this workshop. His bio is provided in Section 9.2.1.

9.6.1. Bios for Keynote Speakers

Keynote 1: **General Joseph Votel**, CEO, Business Executives for National Security

Bio: General Joseph Votel: Continuing his long, distinguished career of service and senior leadership, General Votel today serves as President and CEO of Business Executives for National Security (BENS) – a national, nonprofit comprised of senior business and industry executives who volunteer their time and expertise to assist the U.S. national security community. In this role, General Votel leads a driven, multidisciplinary staff – spread across seven regional offices – and advises and executes on the strategy put forth by the BENS Board of Directors and the organization's 400+ dedicated members.

General Votel joined BENS in January 2020 following a 39-year military career where he commanded special operations and conventional forces at every level; last serving as the Commander of U.S. Central Command (CENTCOM) where he was responsible for U.S. and coalition military operations in the Middle East, Levant, and Central and South Asia. General Votel's career included combat in Panama, Afghanistan, and Iraq. And he notably led the 79-member coalition that successfully liberated Iraq and Syria from the Islamic State Caliphate. General Votel preceded his assignment at CENTCOM with service as the Commander of U.S. Special Operations Command and the Joint Special Operations Command.

General Votel has been recognized with the Distinguished Military Leadership Award from the Atlantic Council and has received the U.S.- Arab Defense Leadership Award from the National Council on U.S.-Arab Relations; the Patriot Award from the National Medal of Honor Society; the SGT James T. Regan Lifetime Achievement Award from the "Lead the Way" Foundation; and the Freedom Award from the Intrepid Sea, Air and Space Museum.

He is a Strategic Advisor for Sierra Nevada Corporation as well as a member of the Board of Trustees for Noblis Corporation. Votel is a non-resident Distinguished Fellow at the Middle East Institute in Washington, DC and the Belfer Center at the John F. Kennedy School of Government in Cambridge, MA. He sits on the Executive Board of the Center for Ethics and the Rule of Law (CERL) at the University of Pennsylvania Law School and is an Advisor to the Combating Terrorism Center at West Point, NY. He serves on the Board of Directors for both Service to School and Minnesota Wire and also serves as an Advisor to the Texas Transition Network. He is a member of the Council on Foreign Relations.

General Votel is a 1980 graduate of the United States Military Academy and earned his Master's Degrees from the U.S. Army Command and Staff College and the Army War College.

Keynote 2: **Brian Strom**, **MD, MPH**, Chancellor, Rutgers University Biomedical and Health Sciences

Bio: Dr. Brian L. Strom is Inaugural Chancellor of Rutgers Biomedical and Health Sciences and the Executive Vice President for Health Affairs at Rutgers University, Dr. Strom has spearheaded the creation of an interprofessional faculty practice group; established a formal partnership with RWJBarnabas Health to create the New Jersey's largest and most comprehensive academic health system; and led a major recruitment drive to bring the nation's most talented biomedical researchers and clinicians to Rutgers. Prior to joining Rutgers, Dr. Strom was the Executive Vice Dean for Institutional Affairs, Founding Chair of the Department of Biostatistics and Epidemiology, Founding Director of the Center for Clinical Epidemiology and Biostatistics, and Founding Director of the Graduate Program in Epidemiology and Biostatistics, at the Perelman School of Medicine of the University of Pennsylvania. In addition to writing more than 650 papers and 15 books, he has been principal investigator for more than 275 grants, including over $115 million in direct costs alone. He was honored as one of the Best Doctors in America, for each of his last eight years at Penn.

Dr. Strom's major research interest is in the field of pharmacoepidemiology, the application of epidemiologic methods to the study of drug use and effects. He is recognized as a founder of this field and for his pioneering work in using large databases for research. He is editor of the field's major text (now in its sixth edition) and Editor-in-Chief for Pharmacoepidemiology and Drug Safety, the official journal of the International Society for Pharmacoepidemiology.

Dr. Strom was a member of the Board of Regents of the American College of Physicians, the Board of Directors of the American Society for Clinical Pharmacology and Therapeutics, and the Board of Directors for the American College of Epidemiology, the Board of Directors for the Association for Patient-Oriented Research, and the Board of Directors of the Clinical Research Forum. He was previously President of the International Society for Pharmacoepidemiology and the Association for Clinical Research Training.

Dr. Strom was on the Drug Utilization Review Committee and the Gerontology Committee of the United States Pharmacopoeia, served on the Drug Safety and Risk Management Advisory Committee for the US Food and Drug Administration, chaired the Institute of Medicine (IOM) (now the National Academy of Medicine) Committee to Assess the Safety and Efficacy of the Anthrax Vaccine, chaired the IOM Committee on Smallpox Vaccine Program Implementation, chaired the IOM Committee to Review NIOSH's Traumatic Injury Program, chaired the IOM Committee on the Consequences of Reducing Sodium in the Population, chaired the IOM Committee on a National Strategy for the Elimination of Hepatitis B and C and the Committee on Development of a Protocol to Evaluate the Concomitant Prescribing of Opioid and Benzodiazepine Medications and Veterans Deaths and Suicides. Dr. Strom was a member of the IOM Committee to Review the CDC Anthrax Vaccine Safety and Efficacy Research Program, and was a member of the IOM Committee on Standards for Developing Trustworthy Clinical Practice Guidelines and the IOM Drug Forum.

Dr. Strom is a member of the American Epidemiology Society, and is one of a handful of clinical epidemiologists elected to the American Society of Clinical Investigation and American Association of Physicians. He has been an elected member of the IOM of the National Academy of Medicine since 2001. He received the 2003 Rawls-Palmer Progress in Medicine Award and the 2016 Oscar B. Hunter Career Award in Therapeutics from the American Society for Clinical

Pharmacology & Therapeutics, the Naomi M. Kanof Clinical Investigator Award of the Society for Investigative Dermatology, and in 2006 he received the Sustained Scientific Excellence Award from the International Society for Pharmacoepidemiology. In addition, he was named the 2008 recipient of the John Phillips Memorial Award for Outstanding Work in Clinical Medicine. This award is from the American College of Physicians (ACP) and is considered to be one of the highest awards in Internal Medicine. Dr. Strom also received the 2013 Association for Clinical and Translational Science/American Federation for Medical Research National Award for Career Achievement and Contribution to Clinical and Translational Science for translation from clinical use into public benefit and policy. Penn awards that Dr. Strom received included the Class of 1992 Class Teaching Award and the Samuel Martin Health Evaluation Sciences Research Award. Dr. Strom received the 2004 Christian R. and Mary F. Lindback Award, the University's most prestigious teaching award, in recognition of the contribution he has made in his career to clinical research teaching. The 2016 Oscar B. Hunter Career Award in Therapeutics was awarded to Dr. Strom for his outstanding contributions to clinical pharmacology and therapeutics. In 2017, Dr. Strom was named Honorary President of The Hellenic Society of Pharmacoepidemiology and in 2018 he was awarded an honorary doctorate from the University of Thrace in Greece. In 2020 he was named as a Fellow of the American Association for the Advancement of Science (AAAS).

9.6.2. Bios for the Panel on Distribution, Allocation, Administration, and Roles of Government

David Adinaro, MD, FACEP, Deputy Commissioner of Public Health Services, New Jersey Department of Health

Bio: Dr. David Adinaro began serving as Deputy Commissioner for Public Health Services on June 18, 2020. As the Deputy Commissioner for Public Health Services, Dr. Adinaro will oversee the Divisions of Epidemiology, Environmental and Occupational Health; Family Health Services; HIV, STD and TB Services; Medicinal Marijuana; Public Health Infrastructure, Laboratories and Emergency Preparedness (PHILEP); and the Offices of Local Public Health and Women's Health. The Division has 660 staff and a $103.5 million budget.

Dr. Adinaro became an EMT as a teenager and volunteered on first aid squads for 17 years including while a student at Rutgers -New Jersey Medical School in Newark. He graduated in 2000 and then completed his residency in Emergency Medicine at Morristown Medical Center in 2003. He is a graduate of Lehigh University's Healthcare Systems Engineering professional master's program and earned a Master of Arts in Education degree in 1993 from Seton Hall University.

He is a fellow of the American College of Emergency Physicians and is a former president, board member and education committee chair of its New Jersey chapter. He also served as the medical director for the Union County College Paramedic Training Program. Dr. Adinaro has lectured extensively in emergency medicine focusing on evidence-based medicine, simulation,

patient safety and opioid prescribing in the Emergency Department and was the director of an innovative fellowship program in Administration and Informatics.

Kevin Ban, MD, Chief Medical Officer, Walgreens

Bio: Dr. Kevin Ban is a physician executive with more than two decades of clinical experience and a track record for optimizing clinical programs, healthcare information systems, and patient safety. Prior to joining Walgreens as Chief Medical Officer, Dr. Ban served as Chief Medical Officer at athenahealth, driving collaborative and strategic initiatives with a specific focus on population health. A board-certified emergency medicine physician with over 24 years of clinical experience, he served as Beth Israel Deaconness Needham's CMO, and was a member of Harvard Medical School's academic faculty from 2003-2016. Dr. Ban led the Tuscan Emergency Medicine Initiative from 2003-2010 — driving success in emergency medicine education, quality improvement, translational research, and simulation training in the region — and launched the first pediatric trauma center in Italy where he served as Chairman of the program. He received his BA and MD from Georgetown University, and completed his Emergency Medicine training in the Beth Israel Deaconess Harvard Affiliated Emergency Medicine Residency program.

Karin Shanahan, SVP, Merck

Bio: Karin Shanahan has nearly 25 years of experience in the pharmaceutical industry, beginning her pharma career with Bristol-Myers Squibb in their global supply chain organization. Working with a cross-functional team, Ms. Shanahan helped Bristol-Myers Squibb design the Product Development & Commercialization process; later leading the launch readiness for the Abilify launch. She moved into manufacturing operations to lead two manufacturing operations, first a radio-pharmaceutical operation in Billerica, MA and then the networks' largest API and DP site in Latina, Italy. She left BMS to join Becton Dickenson as VP, Global Operations supporting their Pre-Analytical Services business unit. After a brief role with Catalent Pharmaceuticals, she moved to Teva Pharmaceutical as SVP, Americas & EU Sterile Operations where she had responsibility for 24 sites in Canada, US, Latin America and Europe. During her 5 years at Teva, Shanahan created the MS&T (Manufacturing, Science & Technology) organization to enhance product launch capabilities, took on responsibility for network strategy and was globally responsible for Operational Excellence. She recently joined Merck as SVP, Global Biologics and Sterile Operations where she has operational responsibility for Keytruda and an IO pipeline of products. In this role, she is also accountable to supply several vaccines, most notably Gardasil. Prior to joining the pharma industry, she held supply chain roles at Daimler Benz and the U.S. military in her hometown of Berlin, Germany. She holds a BA in Political Science &

International Relations from Rutgers University and is earning her MSJ in Pharmaceutical and Device Law at Seton Hall University.

Marion Whicker, Deputy Chief of Supply, Production and Distribution, Operation Warp Speed

Bio: Marion Whicker was selected to the Senior Executive Service in June 2018 and is currently serving as the Executive Director of the Integrated Logistics Support Center (ILSC), U.S. Army Tank-automotive and Armaments Command. In this position, Ms. Whicker oversees the readiness of the majority of Army maintenance, fielding, new equipment training, supply chain management and system readiness. Ms. Whicker has direct oversight for a major Integrated Materiel Management Center with over 3,200 combined military and civilians. She provides the senior leader logistical support to almost 500 (63% of the Army's) new acquisition programs, as well as the sustainment support for over 10,000 major end items, ensuring operational readiness and support to the majority of the Army's major weapon systems. She provides leadership of a major logistics organization to include Weapon Systems Program Management, Materiel Management, Maintenance, Customer Support/Readiness, Integrated Logistic Support, and logistics support to five Program Executive Offices and associated Program/Project/Product Manager Offices.

9.6.3. Bios for the Panel on Supply Chain Issues

Leonardo (Len) DeCandia, Chief Procurement Officer, Johnson & Johnson

Bio: Leonardo (Len) DeCandia is Global Chief Procurement Officer at Johnson & Johnson (NYSE: JNJ), an $82 billion maker of pharmaceuticals, medical device and consumer health products with 140,000 employees around the world.

Mr. DeCandia rejoined Johnson & Johnson in 2014 after a previous tenure from 1982 to 1996. He assumed his current role in 2016. As Chief Procurement Officer, he is responsible for all global procurement policies, including supplier base strategy development, practices such as relationship management and functional headcount. He also serves as a member of Johnson & Johnson's enterprise governance and corporate governance councils. He spearheaded an enterprise-wide functional transformation, from a decentralized procurement system to a center-led model, covering all categories of spend for Johnson & Johnson globally. He also led the deployment of the world's largest cloud-based procurement technology, which processed more than $50 billion in spend for a $5.2 billion cost savings in the first three years.

From 2009 to 2014, DeCandia was Chief Procurement Officer and Senior Vice President for Estée Lauder (NYSE: EL), where he was accountable for all global procurement functions

totaling $4.5 billion in spend, including direct materials and third-party manufacturing. He managed the deployment of all global strategies for major categories, such as chemicals, plastics, glass and packaging, leading the enterprise to a five-year cumulative savings of $722 million.

Previously, he was Senior Vice President, Supply Chain Management, at AmerisourceBergen (NYSE: ABC) from 2004 to 2008. He was responsible for all of AmerisourceBergen's $51 billion procurement functions as well as $4 billion in inventory management activities involving the distribution of branded, generics and over-the-counter pharmaceutical products. He also held general management responsibility for the $4 billion generics business. DeCandia is the founding chair (2002) of the Rutgers University Center for Supply Chain Management and he is currently a member of the advisory board at the Rutgers Business School. He was also a previous chairman of the Healthcare Distribution Alliance industry board from 2006 to 2008.

Len DeCandia holds a bachelor's degree in Mechanical Engineering and a master's degree in Business Administration from Rutgers University.

Brandon Fried, Executive Director, Air Forwarders Association

Bio: Brandon Fried has more than 38 years of experience in the airfreight forwarding industry. While still a forwarder, Mr. Fried joined the Airforwarders Association and was soon elected Chairperson in 2001. He served two consecutive terms as Chair and remained an active member of the Board of Directors. In November of 2005, he was appointed to serve as the new executive director of the Airforwarders Association. As executive director, he represents the Association on all security matters and serves several Federal Advisory Committees including:

- The TSA Aviation Security Advisory Committee
- The U.S. Department of Commerce Committee on Supply Chain Competitiveness
- CBP Commercial Operations Advisory Committee

He also now chairs and represents forwarder interests on the advisory Board of Cargo Network Services, an IATA company.

Mr. Fried advocates for the industry in the halls of Congress, the Department of Homeland Security and is the public face of the Airforwarders Association. He is a recognized expert on the air cargo industry and regularly comments for major trade publications such as *American Shipper*, *The Journal of Commerce and Air Cargo World.* He also continues to educate and advocate for forwarders in national publications, including the *Washington Post*, *the Wall Street Journal*, *the Chicago Tribune*, the *Los Angeles Times, The Miami Herald and USA Today.* He has also appeared on National Public Radio, CNN News and C-SPAN's *Washington Journal* television shows.

A graduate of Syracuse University, Brandon Fried holds a master's degree in business administration and lives in Chevy Chase, Md. with his wife and two children.

Reggie Jackson, Senior Manager Supply Chain Security, Pfizer Global Security

Bio: Reggie Jackson has worked for Pfizer for 20 years. For the last 6 years, he has worked and led the efforts around Supply Chain Security for Pfizer globally. These duties include preventing, detecting and responding to incidents of theft, counterfeiting, diversion, and adulteration of all Pfizer products intended for the legitimate supply chain. He is the Supply Chain Security Steering Committee chair for Rx-360 and sits on Rx-360's Board of Directors. Reggie Jackson has a BS in Chemical Engineering and an MBA from North Carolina State University.

Shellie Martin, Kodiak Area Native Association

Bio: Shellie Martin is a level III Certified Community Health Aide, Emergency Medical Technician, and member of the Community Health Aide Program Association in the State of Alaska. She is employed by the Kodiak Area Native Association and has been a front-line worker for the past 3 ½ years, travelling between five remote villages in the Kodiak archipelago to provide primary health care and after-hours emergency services to their residents.

The Alaska Community Health Aide Program has improved remote access to healthcare for rural Alaskans living in Native village communities by developing a paraprofessional workforce. The structured progressive training for the Community Health Aide Program has created a clinically competent group of women and men who make up the backbone of primary rural health care in Alaska.

Jere Miles, Department of Homeland Security, Homeland Security Investigations

Bio: Jere Miles is the Assistant Director (AD), Operational Technology and Cyber Division, Homeland Security Investigations, Washington, DC. In his current assignment he exercises oversight of the enterprise wide Law Enforcement Technology; uses, R&D, purchasing and deployment, the global Cyber Investigations program; policy development, implementation and oversight as well as training of all cyber investigators and analysts dedicated to cyber forensics, intrusions or digital technology facilitated criminal activity. Additionally, he oversees HSI's enterprise wide investigative databases, big data project and global information sharing.

Prior to beginning his career as a Federal Criminal Investigator, AD Miles served in the United States Army's 82nd Airborne Division, from 1984 until 1992, participating in Operation "Just Cause". After his honorable discharge, he served as a Deputy Sheriff in South Carolina from 1993 – 1999, holding the positions of Patrol Deputy, Vice Detective, and Resident Deputy Investigator.

He began his federal career in November 1999, with the U.S. Customs Service as an Air Enforcement Officer. In December 2000, he was converted to a Criminal Investigator and

assigned to work in the U.S. Customs Service (USCS), Special Agent in Charge (SAC), Miami, FL. During his Federal career AD Miles has spent seven years overseas, Republic of Mexico, and held numerous leadership positions in both Homeland Security Investigations field offices and Headquarters.

Edward (Ted) Smith, Alaska Native Tribal Health Consortium (ANTHC)

Bio: Edward (Ted) Smith has seventeen years of emergency preparedness/response experience in the State of Alaska. He is currently responsible for the coordination and development of emergency plans and programs for ANTHC, Tribal hospitals, clinics, tribes and Alaska communities. Prior to his work for ANTHC he served as an Emergency Planner for the Department of Health & Social Services' (DHSS) Section of Emergency Programs. His primary responsibilities included providing technical assistance for all departmental emergency planning needs, teaching/advising on emergency management issues at the community level, and he served as the State's Coordinator for the Strategic National Stockpile and the Hospital Preparedness Program. Previous to this position, Mr. Smith worked for the Alaska Division of Homeland Security and Emergency Management (DHS&EM) as an Emergency Management Specialist.

9.7. Workshop on Suez Canal Incident Impact and Implications for the Global Maritime Supply Chain

9.7.1. Bio for Keynote Speaker

Keynote: **Rear Admiral Brian K. Penoyer,** Commander, U.S. Coast Guard District Eleven

Bio: Rear Admiral Brian K. Penoyer assumed his duties as Commander, Eleventh Coast Guard District in July of 2020. As such, he oversees the Coast Guard's safety, security, law enforcement and environmental stewardship operations from the California-Oregon border to Peru including Arizona, Utah, and Nevada. He previously served as Commander, Coast Guard Force Readiness since July 2018. The Force Readiness Command directs the activity of 41 subordinate units in 17 states impacting every Coast Guard Mission. Prior to his assignment as the Commander, Force Readiness Command, Rear Admiral Penoyer commanded the Fourteenth Coast Guard District, where he directed all Coast Guard missions across the Central and South Pacific, an area spanning over 12.2 million square miles and including the Hawaiian Islands, Guam, American Samoa, and the Commonwealth of the Northern Marianas, with additional activities in Singapore and Japan.

Rear Admiral Penoyer has extensive operational experience with a specialty in coastal operations. During his career, he has served as the Commander of Coast Guard Sector Houston-Galveston, as the Deputy Commander at Coast Guard Sector Maryland/National Capitol Region, and at Sector Jacksonville, Florida. He was the liaison in the office of the Deputy Secretary of Homeland Security during the Deepwater Horizon incident, deployed during Hurricane Katrina to Louisiana, and again during the Hurricane Sandy to New York. In other operational assignments, he inspected foreign and U.S. merchant vessels, led oil spill response teams, and conducted investigations in Alaska during a period of multiple cruise ship groundings and significant, fatal commercial fishing vessel accidents. In his first assignment for the Coast Guard, he deployed throughout Europe and the Middle East during the 1991 Gulf War.

Rear Admiral Penoyer's staff assignments include serving as the Chief of Staff at the Fourteenth Coast Guard District, as deputy Chief of Coast Guard Congressional Affairs, as a military fellow at the Center for Strategic and International Studies, and as Department of Homeland Security's Chief of Contingency Planning. He also served as the Coast Guard's liaison to the U.S. Department of the Interior and Coast Guard representative on the National Response Team. Rear Admiral Penoyer holds a Bachelor's degree from the University of Chicago, a Master of Public Policy degree from the University of Maryland, and a Master of Arts in National Security and Strategic Studies from the Naval War College. He is a 2015 recipient of the Coast Guard's Type I Incident Commander qualification.

He has been awarded two Legion of Merits, five Meritorious Service Medals, three Coast Guard Commendation Medals, the Department of Transportation "9-11" Medal, and several campaign medals including the Southwest Asia Service Medal.

9.7.2. Bios for the Overview Panel

CREATE Director Adam Rose moderated the panel. His bio is provided in Section 9.2.2.

Capt. Andrew Tucci served on the panel. His bio is provided in Section 9.2.1. Bios for the other panelists follow.

Capt. Lawson Brigham, U. S. Coast Guard (ret.)

Bio: **Capt. Lawson Brigham** is a Fellow in the Wilson Center's Polar Institute. He is a former researcher at the University of Alaska Fairbanks and a Fellow at the U.S. Coast Guard Academy's Center for Arctic Study & Policy. Captain Brigham was a career Coast Guard officer and commanded four cutters including the icebreaker Polar Sea on Arctic & Antarctic expeditions. During 2004-09 he was chair of the Arctic Council's Arctic Marine Shipping Assessment. He is a graduate of the Coast Guard Academy and earned his PhD at Cambridge University. Dr. Brigham is a member of the National Academies Polar Research Board and is a Council on Foreign

Relations member. His research interests have focused on the Russian maritime Arctic, environmental change, polar marine transportation, and polar geopolitics.

Capt. David Moskoff, USMS, United States Merchant Marine Academy

Bio: Capt David Moskoff is a Professor at the United States Merchant Marine Academy and has served there as Head of the Department of Marine Transportation, Assistant Academic Dean, and Faculty Forum President. He is a Senior Expert Advisor to NATO's Transport Group for Ocean Shipping, Senior Advisor to the DoD's Purposeful Interference Response Team (PIRT) under US SPACE COMMAND, serves as a DoT/MARAD representative to other federal entities, has represented US DHS abroad, and has made numerous presentations throughout the United States and internationally by request. Capt. Moskoff is also President of MARITECH, a marine consulting and maritime services firm. He has been certified American Bureau of Shipping (ABS) Surveyor, certified ABS/QE ISO/ISM third party external Lead Auditor as well as third party auditor for the American Waterways Operators' Responsible Carrier Program. He is a certified Vessel Security Officer (VSO), Facility Security Officer (FSO) and Company Security Officer (CSO). He served as the first Mooring Master at Sea-3's LPG ship terminal in New England. He has held a USCG Unlimited Master's License for over three decades and has commanded both steam and diesel ships. Capt. Moskoff holds a BS in Marine Transportation (SUNY Maritime) and MS in Information Technology (AIU).

Nathaniel "Sam" Ruda, Director, Port Department, Port Authority of NY & NJ

Bio: **Sam Ruda** was appointed Director of the Port Authority's Port Division on April 15, 2019. Mr. Ruda joined the Port Authority of NY & NJ as the Assistant Director, Port Business Development, in August of 2015. In that role, he had oversight for the retention and growth of the Port's maritime business segments: auto, bulk, containers, and cruise. Additionally, this role had oversight of the Port's marine property and leasing division. In December of 2016, Mr. Ruda was named Deputy Director with additional responsibilities covering port performance initiatives and innovation. In October of 2018, he was named Acting Port Director.

Prior to joining the Port Authority of NY & NJ, Mr. Ruda was Chief Commercial Officer (CCO) for the Port of Portland (Oregon). In this role, he had responsibility for the maritime and aviation business activity in addition to the Port's industrial real estate portfolio. From 2003 to February of 2012, he was the Director of Marine and Industrial Development at the Port of Portland.

Born and raised in New Jersey, Mr. Ruda began his career as a management trainee with the global container carrier Sea-Land Service. He has also held sales and management positions with American President Lines and NYK Line. From 1997-2001 he was Coordinating Manager for NYK's North American Liner division based in Tokyo, Japan and later had responsibility for North Asia Marketing and Pricing based in Hong Kong, PRC. Sam Ruda holds a bachelor's degree in economics from Rutgers University.

Henry Willis, Homeland Security Operational Analysis Center (HSOAC)

Bio: **Dr. Henry Willis** is director of the Homeland Security Operational Analysis Center (HSOAC) Strategy, Policy, and Operations Program; a senior policy researcher at the RAND Corporation; and a professor of policy analysis at the Pardee RAND Graduate School. He is a recognized expert in homeland security risk management. Recent work analyzes terrorism warning indicators; border security efforts; critical infrastructure resilience; and national preparedness to chemical, biological, nuclear, and radiological attacks.

Dr. Willis is an active contributor to policy research, having served as the risk management research theme leader at the CREATE DHS COE and as a principal investigator at the BORDERS DHS CO. Through his work he testified before Congress; served on several committees of the National Academy of Sciences; advised government agencies across the United States, Europe, Australia, and the United Arab Emirates; and published dozens of journal articles, reports, and op-eds on applying risk analysis to homeland security policy. Willis is the treasurer of the Society for Risk Analysis and has served on the editorial board of the international journal Risk Analysis. His work in homeland security policy evolved from his work on program evaluation at the White House Office of Management and Budget and infrastructure design as a water and wastewater engineer. He earned his Ph.D. in engineering and public policy at Carnegie Mellon University.

9.7.3. Bios for the Panel on Impacts of the Suez Disruption and other Multiple, Complex Disruptions

Capt. Andrew Tucci moderated the panel. His bio is provided in Section 9.2.1.

Brandon Fried served on the panel. His bio is provided in Section 9.6.3. Bios for the other panelists follow.

Capt. Eric Johansson, SUNY Maritime College

Bio: Capt. Eric Johansson is a third generation Port of NY/NJ Tug Captain and Distinguished Service Professor at SUNY Maritime College, located in NYC. The Distinguished Service Professorship is the State University's highest academic rank and conferred by the State University Board of Trustees for having a distinguished reputation for service to the campus, University, community, State of New York, and Nation. Since joining the faculty in 1994, he enjoys teaching and mentoring future professional mariners in areas of Towing, Shipping, Marine Spatial Planning, Leadership, and Ship Systems. Captain Johansson is a recipient of the Chancellor's Award for Excellence in Teaching, Chancellor's Award for Excellence in Faculty Service, Plimsoll Award, and the Public Service Commendation (United States Coast Guard). Captain Johansson is the founder of the annual SUNY Maritime College Towing Forum, now in its 18th year, and has published funded research projects including the Maritime Support Service Location Study I, Brooklyn Navy Yard Development Corporation "Economic Analysis", Small Business Dredge Needs Port of NY Study, New Jersey Offshore Wind Outlook, "Economic Impact of Siltation on NYC's Small Waterways" and "Hunts Point Terminal Market: The Demand for Waterborne Transportation as a Part of the Outbound Distribution System". In addition to his research, Captain Johansson serves on many local maritime committees such as Harbor Safety Committee, Energy Sub-committee, and nominated by the Department of Homeland Security as Vice Chair of the Towing Safety Advisory Committee. He holds a Master of Science in International Transportation Management from SUNY Maritime.

Capt. Zeita Merchant, Sector Commander, Sector New York, U.S. Coast Guard

Bio: Capt. Zeita Merchant assumed the duties of Commander, Sector New York in May 2020, overseeing the daily operations of Sector New York's over 900 personnel, seven cutters, three small boat stations, two aids to navigation teams, and vessel traffic management system. Prior to joining Sector New York, Captain Merchant was a National Security Fellow at Harvard University's Belfer Center for Science and International Affairs.

Enjoying over 23 years of active duty service, Captain Merchant is a recognized authority in the complex maritime safety and security and emergency management fields. She has served in a variety of assignments at the operational and strategic levels and has been certified as one of the Coast Guard's top Emergency Managers leading large-scale, multijurisdictional incident responses from Texas to Puerto Rico. Her operational assignments include commanding maritime operations across the southern tip of Lake Michigan at Marine Safety Unit Chicago. She also directed operations as the Executive Officer of Marine Safety Unit Texas City, Chief of Port Operations at Sector Miami and as a Marine Inspector and Port Operations Officer at Marine Safety Office New Orleans.

Her previous staff assignments include serving as the Special Assistant to the 27th and 28th Vice Commandants of the Coast Guard, Congressional Fellow on the Committee of Oversight and Reform and Committee on Transportation and Infrastructure and Executive Strategic Planner for Coast Guard Flag and Senior Executive Service Corp.

Captain Merchant holds a Doctorate of Business Administration and Master of Quality Systems Management from the National Graduate School at New England Institute of Business as well as a Master of Public Administration from George Washington University and a Bachelor of Science in Biology from Tougaloo College. In addition, she is a graduate of the Harvard Kennedy School of Government's Executive Education Leadership in Homeland Security Course and a Massachusetts Institute of Technology (MIT) Seminar XXI National Security and Foreign Affairs Fellow.

She has been honored with numerous professional, academic, and community service awards, including the 2019 Network of Schools of Public Policy, Affairs, and Administration Outstanding Achievement in Public Service, 2018 Chicago Federal Executive Board J.F. Kennedy Leadership Award, 2018 USCG Captain Jarvis Inspirational Leadership Award, 2017 USO LTC James M. O'Rourke Service Salute Award and many more. Her personal military awards include three Meritorious Service Medals, six Coast Guard Commendation Medals, three Coast Guard Achievement Medals, three Military Outstanding Volunteer Service Medals, and four Commandant's Letters of Commendation, Marine Safety Insignia and Commandant's Staff Identification Badge.

Gabriel Weaver, Information Trust Institute, University of Illinois at Urbana-Champaign.

Bio: Dr. Gabriel Weaver is a Research Scientist at the Information Trust Institute at the University of Illinois at Urbana-Champaign. Currently, his research focuses on ways to analyze cross-organizational, inter-infrastructure risk as modern information systems are increasingly used to control and monitor critical infrastructures including the bulk electric and maritime transportation systems. As the Herman M. Dieckamp Inaugural Fellow, his research has focused on better ways to assess the resilience of critical infrastructure systems with a particular focus on the Maritime Transportation System (MTS). Gabriel Weaver holds a Ph.D in Computer Science from Dartmouth College, where his dissertation was entitled *Security-Policy Analysis with eXtended Unix Tools* and advised by Professor Sean Smith. Dr. Weaver also holds a B.A. in Classics and Mathematics from the College of the Holy Cross.

9.7.4. Bios for the Panel on Types of Disruptions, Present and Future, Mitigation and Response

General Randy “Church” Kee, Executive Director of ADAC, moderated the panel. His bio is provided in Section 9.1.2.

Casey Hehr, Director of Security, Port of Long Beach, California

Bio: Casey Hehr is the Director of the Security Division at the Port of Long Beach, California. He was named to the position of Director of the Security Division in 2018 by the Long Beach Board of Harbor Commissioners after serving for two years as the Assistant Director of Security for the port. As the Director of Security, Mr. Hehr administers a staff of over 100 personnel and the division’s budget of more than $40-million. He leads the division’s Joint Command and Control Center and external engagement, emergency management, grants and administration sections. He also provides liaison with more than 80 public safety and security partners throughout the region.

Before coming to the Port, Mr. Hehr spent nearly eight years serving the Long Beach/Los Angeles maritime community, most recently as the Chief of Response for the U.S. Coast Guard, leading port security operations, law enforcement, search and rescue, and pollution response. Before coming to Southern California, Mr. Hehr was assigned to the Office of the Secretary of Homeland Security in Washington, where he provided immediate support to Secretaries Ridge and Chertoff for Homeland Defense and Maritime Security Policy and Operations. While assigned to the Secretary’s office, he was a member of the White House National Security Council’s team that developed the United States’ first National Strategy for Maritime Security signed by the President.

Mr. Hehr is a graduate of the U.S. Coast Guard Academy where he earned a Bachelor of Science degree with honors in Mechanical Engineering and his commission as an officer. He also earned a Master of Business Administration degree from Boston College’s Carroll School of Business.

Bethann Rooney, Deputy Director, Port Department, Port Authority of NY & NJ

Bio: Bethann Rooney is the Deputy Director of the Port Department of the Port Authority of New York and New Jersey; the Nation’s third largest port. She is responsible for managing the day-to-day administrative and operations functions of the Port, including facility management, infrastructure, planning, environmental sustainability, port efficiency, business development, finance, and human resources. She was named to the position in April 2019 after serving four and a half years as the Port’s Assistant Director, Strategy and Innovation. She is the architect and coordinator of the Port’s Council on Port Performance; the first forum of its kind in the nation that was established as a framework for port constituents to identify challenges to port efficiency and service reliability and

develop recommended solutions. Prior to that, Ms. Rooney was the General Manager, Port Security for the Port Authority for 13 years. Assuming this post in the immediate aftermath of the 9/11 tragedy, she is a recognized world leader in maritime security and emergency management issues. A 28-year veteran in the maritime industry, she is a graduate of the State University of New York Maritime College with a Masters in International Transportation and a Bachelors in Marine Transportation with qualifications as a Third Mate. Ms. Rooney holds several professional certifications and is an Accredited Marine Port Executive from the International Association of Maritime and Port Executives.

Capt. Phil Thorne, USCG (Ret), USCG District 17 Arctic Program Specialist

Bio: Capt. Phil Thorne served as the Alaska regional Coast Guard Arctic Program Specialist, where he Thorne coordinated Coast Guard activities across the Arctic domain, advanced Coast Guard strategic planning on Arctic-related issues, and advised senior leadership, staff and field units on international and domestic Arctic matters. Prior to his role as the Arctic Program Specialist, Capt. Thorne served in numerous leadership roles in the USCG Alaska Region, including Sector Commander, Chief of Response, Chief, Response Enforcement Branch, and Chief, Response Department.

Kim Young-McLear, Cybersecurity and Infrastructure Security Agency and U.S. Coast Guard

Bio: Dr. Kimberly Young-McLear is a scholar, engineer, cyber professional, and educator who is unreservedly committed to human resilience. She has been a homeland security professional since 2003, serving on active duty in the U.S. Coast Guard. In that time she has been assigned to numerous technical positions including in Cyber, Marine Safety, Naval/Industrial Engineering, and Academia. Earlier in her career, she also served as Special Assistant to the Deputy Secretary of Homeland Security (DHS) where she provided direct support to a Deputy Cabinet Secretary for the development of DHS policy, mission planning, and execution for 240K employees.

She holds formal degrees from Florida A&M University, Purdue University, and The George Washington University. She is tenured faculty at the Coast Guard Academy on detail at the Cybersecurity and Infrastructure Security Agency. Her focus applies her many passions and areas of expertise to addressing the 500K national shortage of cybersecurity professionals, while identifying methods to systematically increase diversity.