ElectroMagnetic Pulse, GeoMagnetic Disturbance Events, and the Transportation Sector

By Bruce Churchill

The Transportation Sector is arguably the most complex of the so-called "critical lifeline" sectors, being made up of no less than seven sub-sectors. Part of this sector is physical infrastructure and part is control systems with their associated communications networks. An ElectroMagnetic Pulse (EMP) attack or GeoMagnetic Disturbance (GMD) event will likely leave the physical infrastructure intact but will significantly impact transportation network control systems. Post-EMP/GMD recovery efforts will require resiliency of the transportation sector to support other critical needs, such as life safety, movement of critical supplies and personnel and support to other critical infrastructure sectors. For example, the transportation system will be critical to the recovery of the electrical grid by moving repair vehicles and equipment to high priority impacted areas. Transportation sector emergency planning must consider a new set of assumptions that recognize the loss of the electrical grid for periods exceeding one month. Perhaps the best example of regional planning has been done in the San Francisco Bay Area but even here the worst-case scenario falls short of this planning factor. Regional planning is key to building resilience into the transportation sector and would be of greatest value if regional plans are interoperable across the nation.

Introduction

Overview

The Transportation Sector is arguably the most diverse and far-reaching of the 16 PPD-21 designated Critical Infrastructure sectors.[1] The sector consists of physical infrastructure, control systems, vehicles and people that operate and control aviation, maritime, highway, public transportation, rail, pipelines and the combinations of these that constitute supply chain logistics. The latter includes maritime, rail, aviation and highway components of intermodal freight movement. Standard intermodal containers are interchanged among maritime, rail and commercial truck vehicles while air freight containers are interchanged among air freight and commercial delivery vehicles. The former operates at ports, both maritime (ship>rail>truck) and inland (aka "dry ports" - rail>truck). The latter typically operate at airport freight terminals (air>truck). Other than Finance and Banking, Transportation has the most extensive assets deployed overseas, both military and civilian.

Physical Infrastructure

Transportation physical infrastructure consists of a wide variety of elements including:

- Highway networks (Interstate, state routes, toll roads and local arterials)
- Rail networks (principally owned by freight railroads but used on a shared basis by passenger rail providers albeit at lower priority than freight movement)

[1] Presidential Policy Directive/PPD-21. February 12, 2013. Critical Infrastructure Security and Resilience.

- Airports and navigation aids for the National Airway System
- Ports (container, break bulk, LNG, Tanker, Auto, etc.)
- Navigable waterways and associated aids to navigation
- Supporting facilities and communications networks

factors (e.g. space weather, cyber-attack), most likely control systems will not. Control systems require electrical power, communications and people and consist of the elements referenced in Table 1.

Table 1: Transportation Control Systems

Mode	***Control System***	***Agency Responsible***	***Communications***
Aviation	TRACON	FAA	VHF, UHF
	ATC Centers	FAA	VHF, UHF
	Control Towers	FAA	VHF, UHF
	Radar	FAA	uWave, Fiber Optic (FO), Landlines
	NavAids	FAA	GPS, VHF
Maritime	AIS	USCG, IMO	Satellite
	VTS	USCG	uWave, Fiber Optic, Landline, VHF
	Radar	USCG, Port Owners	uWave, FO, Landlines
	NavAids	USCG, NOAA, IHO	GPS, terrestrial typically not RF
Rail	Signals	Owning RR	FO, Cable
	Control Centers	Owning RR	VHF
	Automated Train Control	Owning RR	
Highway	TMC	Local Jurisdictions & state DOT	VHF
	Signal Control	Local Jurisdictions & state DOT	Various RF and Landline
Public Transportation	Dispatch Centers	Transit Agencies	VHF, UHF
	Train Control Centers	Commuter & Light Rail Operators	VHF, UHF
Emergency Services	Dispatch Centers/PSAP	Local/Regional Jurisdictions	Various terrestrial RF
	EOC	Local/Regional Jurisdictions	Various including SatCom & ARO
Pipelines	Monitoring Centers	Pipeline Owner	Various terrestrial RF

Control Systems

While most transportation physical infrastructure will likely survive an EMP or extended grid outage from other causative

Vehicles

Vehicles move on the physical infrastructure and are independently operated or under automated control. It is not clear how various

types of vehicles will be impacted by an EMP or GMD attack. This applies to all vehicles, whether electric-, diesel- or gasoline-powered. Vehicles consist of:

- Aircraft – military, commercial and privately-owned
- Ships – military, commercial and privately-owned
- Rail cars – freight, light rail, commuter rail, inter-city passenger rail
- Buses – mass transit, inter-city and privately-owned
- Cars and trucks – commercial and privately-owned
- First responder vehicles

People

People are essential to the operation of any transportation system. This may seem obvious, but people needs are often overlooked or given low priority in planning efforts. Transportation system operators fall into a wide variety of skills:

- First responders
- Disaster Service Workers
- Ground vehicle drivers (emergency vehicles, cars, buses, trucks)
- Port terminal operators
- Ship and vessel crews
- Pilots and air controllers
- Control system operators
- Railroad crews (engineers, signal operators, yard managers, dispatch operators)
- Pipeline operators
- Emergency dispatchers

In some areas and under designated circumstances, such people are issued Transportation Worker Identification Credentials (TWIC) to allow access into disaster-impacted areas.

Lessons Learned

There are few well-documented instances where we have hard evidence of the impact of long-term power outages on the transportation network. In recent years, the 2003 Northeast Blackout, the October 2012 Hurricane Sandy event in the Mid-Atlantic states and the September 2017 Hurricane Maria event in Puerto Rico can provide a glimpse into expected outcomes for the Transportation Sector. Arguably the most extensive of these in terms of area impacted if not time of impact, was the 2003 Northeast Blackout. This event is also the closest in expected impact to a projected EMP event. However, the most severe impact in terms of time was Puerto Rico where massive power outages persisted for weeks, not days. We must take care in interpreting these lessons and recognize that although all three events resulted in massive power outages, there were significant differences in factors such as prior warning, cause of the outage and physical damage to the infrastructure. The lessons provide common value in that in each case reconstituting the transportation network was a challenge. In the 2004 Public Roads Magazine (FHWA Vol 68 Nr 2), the then FHWA's Team Leader for Emergency Transportation Operations (ETO) had this to say:

> Restoring transportation operations is vital to safety, freight movement, and national security. "Historically, transportation has been viewed as an important support function during disasters," says the Federal Highway

> Administration's (FHWA) Emergency Transportation Operations Team Leader Vince Pearce. "But the more we look at large-scale situations, the more we see that if transportation doesn't work right, it's too hard for other responders to do their jobs. If we can't get the fire trucks and ambulances to the scene, we can't put the fires out or help the injured. Transportation must work at its absolute best in these kinds of situations, and our objective is to help the transportation community bring their resources to bear at the most important time.[2]

New York City's and Detroit's transportation impacts from the Blackout were severe and in an EMP attack, these impacts would be similar but more widespread and longer in duration. In addition, many, if not most vehicles may be incapacitated, causing additional road blockages and pedestrian traffic. The following impacts occurred during the Blackout:[3]

- Subway and commuter rail systems stopped, requiring massive passenger evacuations
- Bridges and tunnels were closed or operated at greatly reduced functionality – again evacuations were required
- Citywide traffic signals failed causing massive traffic jams
- First responders were overwhelmed with building rescue efforts and other emergency calls
- Many emergency management and control centers lost power and were required to fall back to manual information processing and telephone communications
- Many critical support systems lost power and had no backups – e.g. card access systems, equipment cooling systems, exhaust fans, etc.
- A shortage of portable generators impacted bringing critical intersection traffic signals back on line

Cross-Sector Considerations

Banking and Finance

If an EMP/GMD event were to occur, some form of financial system must be in place to pay for transportation services. Some services may be pre-contracted, but most will likely be on an ad-hoc basis. The discussion below on Blockchain systems is relevant to this requirement.

Communications

The importance of the Communications Sector to transportation control systems cannot be over-emphasized. This was clearly illustrated in Table 1.

Emergency Services

First responders will rely heavily upon the transportation network for response operations. Damage assessment can likely be handled by drones and serviceable helicopters, but actual rescue and security operations will require vehicles and operable roadways.

[2] Federal Highway Administration. DeBlasio, Regan, Zirker, Lovejoy, & Fichter. 2004. Learning From the 2003 Blackout. https://www.fhwa.dot.gov/publications/publicroads/04sep/04.cfm accessed on March 23 2018.

[3] Ibid.

Energy

See below for Transportation support to the Energy Sector.

Food & Agriculture

The nation's food supply is heavily dependent on transportation resources to move products from farm to table through various stages of food processing, distribution and retail facilities. Even if standard retail outlets are non-functional, food supply will remain a high-priority cargo for the allocation of transportation resources. Most retail grocery stores can only expect to have products on shelves for a maximum of 2-3 days under conditions of grid failure.

National Response Framework (NRF) Emergency Support Function (ESF)[4]

ESF #1 provides the Transportation response that will be coordinated by the U.S. Department of Transportation. The key requirement is to establish and maintain critical transportation capability.

ESF #1 coordinates the support for management of transportation systems and infrastructure, the regulation of transportation, management of the Nation's airspace, and ensuring the safety and security of the national transportation system. Functions include but are not limited to:

- Transportation modes management and control
- Transportation safety
- Stabilization and reestablishment of transportation infrastructure
- Movement restrictions
- Damage and impact assessment.

These functions will be further explored in the following sections.

Transportation Sector Resilience Requirements

In the event of an extended grid failure, what should the Transportation Sector do to continue providing its services, presumably at reduced levels that reflect appropriate priorities. For example: reducing the distribution of household water to keep waste water systems and firefighting functional.

Mission Prioritization

Critical services and freight must be prioritized among several critical functions and missions including, but not limited to

- Safety and security
- restoral of electrical grid
- water distribution
- food distribution
- critical personnel staging

Prioritization may differ from region to region depending on condition of local power grid and availability of transportation resources. Critical routes and required services to move high priority freight and personnel to high priority destinations must be identified. Based on these considerations,

[4] U.S. Department of Homeland Security. June 2016. National Response Framework, 3rd Ed. https://www.fema.gov/media-library-data/1466014682982-9bcf8245ba4c60c120aa915abe74e15d/National_Response_Framework3rd.pdf . Accessed on March 29, 2018.

critical control systems and their supporting personnel must be identified and restored to emergency service levels.

Aviation and Maritime Transportation

Air and maritime OCONUS assets must be identified and their repositioning to CONUS prioritized. Some assets will be military, and others will be privately-owned. Critical airports and ports must be identified, prioritized and activated at emergency service levels to support high priority freight and personnel movement. Certain airports and ports will likely be designated as "bridgeheads" to receive high priority cargo and personnel from overseas. Others will be high priority for domestic distribution of critical cargo and personnel. Ports are especially dependent on support equipment such as off-loading cranes and transfer vehicles for intermodal containers and break-bulk cargo. Some consideration should be given to the use of maritime vessels that can create excess power to supply this to port facilities. Ship service turbo-generators are typically fossil-fuel powered steam generators – refueling may have to happen offshore from foreign-flagged tankers. Airports are also dependent on various control and navigation systems that must be brought back to minimum functionality for airports to function as bridgeheads.

Surface Transportation

Interstate and designated state highway systems must be kept clear to facilitate the movement of first responders, high-priority cargo and personnel. This may include limiting traffic movement, roadway clearance of stranded vehicles, suspending toll collections and modifying certain regulatory actions. Fuel supplies and locations will be a critical consideration. The ability of tanker trucks to transfer fuel to non-traditional storage facilities should be investigated. All these factors should be pre-planned to the greatest extent practicable, including legislative actions as needed.

Control Systems

As illustrated in Table 1, control systems are complex, communications and personnel-dependent, vulnerable to EMP, GMD and cyber-attacks, and critical for the safe and efficient operation of their associated transportation network(s). They include remote sensor networks, numerous communications networks, situation displays, computer processing and in some cases at least rudimentary artificial intelligence to aid decision-makers. Control system owner-operators must plan for failure and have in place manual processes and backup communications to ensure minimum operability of their associated transportation networks. This may include micro-grids, ad-hoc networks, RACES and ARES amateur radio emergency communications, backup power systems, and manual data processing procedures and training.

Transportation Sector Support to the Energy Sector

In the event of an extended grid failure, what vital support must the Transportation Sector provide the energy sector to ensure that the grid is brought back on line as quickly as possible, and how would the Transportation Sector deliver that vital support?

Lessons learned tell us that in extended power outages, movement of public utility

vehicles from far-flung regions in the U.S. to impacted areas will be paramount as demonstrated in recent weather-related power outages due 2017 hurricanes and 2018 winter Nor'easters in the Northeast states.

- Physical infrastructure (roads) will likely be operational; however, the control systems that monitor and control traffic movement on this infrastructure will likely not be operable.
- Alternate power service will be prioritized after an EMP attack and high-priority should be given to the movement of electric service restoration vehicles and electrical service critical infrastructure freight movement. Freight rail should be considered an alternate movement means in the event of large-scale roadway shutdowns or blockages.
- Regional planning must consider that higher priority needs outside the region may draw down electric sector response resources within the region. Minimal sustainability and survival assets must be estimated to allocate mutual support to other regions.
- Fuel movement will continue to be a high priority, especially within areas that have limited pipeline access. Diesel fuel will be critical to the operation of emergency generators. One lesson learned from previous power outages is that emergency generator requirements are often overlooked or underestimated.
- A prioritization process with identified critical decision makers must be a part of the post-EMP Emergency Transportation Plan. Many difficult decisions are anticipated following an EMP event and prioritization decision factors should be identified as part of the planning process.

Transportation Sector Recommended Actions to Achieve Resilience

What recommended actions should the Transportation Sector take now - in advance of any future extended grid failure - to ensure its preparedness to take the actions called for above?

National Strategy

Although DHS is preparing a National Strategy and accompanying Implementation Plan to protect the nation against both EMP and GMD contingencies, it is incumbent upon local communities to leverage existing partnerships, facilities and emergency plans to prepare local response and recovery efforts after either an EMP attack or a severe solar storm with potential impacts across the northern hemisphere. The National Strategy deals with estimating threats, vulnerabilities and consequences. Regional planning must address the response and recovery efforts. Mindsets within regional and state emergency planners need to be elevated to think through a catastrophic event that will exceed anything that has been envisioned or planned to date. As the EMP threat, vulnerability and consequence equation is better informed over time as an outcome of the National Strategy, regional planning can be updated to reflect a more accurate assessment of the EMP/GMD/Cyber impact on regional systems, networks, vehicles and critical personnel. Local agencies cannot afford to wait for a better-informed risk analysis.

Regional Planning

A template should be established for regional Emergency Transportation Plans to encourage localized whole-community dialogs for reconstituting regional transportation services after a major power outage. We recommend the planning effort be collaboratively led by regional emergency managers and Metropolitan Planning Organizations (MPOs). The Plan(s) should be jointly supported by the following generic agencies:

- Local and county government representatives
- Transportation providers at the local, regional and state levels (highways, transit operators, rail operators, port and airport authorities)
- Local, county and state law enforcement agencies
- Regional FEMA and DHS representatives including Protective Security Advisors (PSAs)
- Local and state National Guard and DoD components
- Key private sector participants

Post-EMP Response and Recovery Plans should be consistent with, and support the National Recovery Framework, National Incident Management System, existing state and local emergency plans and mutual aid systems. Plans should address the following elements specific to the region:

- Identify Roles and Responsibilities
- Identify backup and emergency communications systems
- Identify alternate sites for key facilities such as EOC's, dispatch centers, shelters, staging centers and distribution points
- Identify and prioritize critical control systems to support traffic management for possible evacuations and movement of critical personnel
- Identify and prioritize critical personnel resources for operations and maintenance of rail and highway networks
- Identify and prioritize ports and airports for OCONUS to CONUS and intra-CONUS movements of ships and aircraft
- Identify and prioritize critical control systems to support aviation, rail and maritime movements
- Identify and prioritize critical personnel resources for operations and maintenance of ports and airports
- Identify and prioritize high priority rail and truck routes for critical freight movement
- Identify the expected support to the region from Defense Support to Civil Authorities (DSCA). This will differ from region to region based on local military and National Guard resources and the region's priority

Ideally these Plans would be created using a standard nationwide template that would allow linkage between regions where deemed feasible by DHS and FEMA. A good starting model might be the San Francisco Bay Area Regional Transportation Emergency Management Plan (RTEMP). This Plan supports major emergencies up to and

including earthquakes and acts of war. [5] [6] The RTEMP is supported by the Regional Emergency Coordination Plan (RECP) that provides a framework for command, control and communications within the impacted operational areas.[7] The RECP has several Subsidiary Plans, among which the Logistics Subsidiary Plan[8] and Transportation Subsidiary Plan[9] are the most relevant to transportation operations. These Plans can be useful in informing a template for regional post-EMP transportation response plans. In reviewing these Plans in their current form (circa 2008), there is a tacit assumption that transportation control systems and their associated communications networks are degraded, but operational – this assumption may not hold for an EMP attack or GMD event. Therefore, some modified assumptions are appropriate.

Post-EMP Assumptions:

- Power outages likely widespread and lasting greater than one month
- Potential communications outages or severely restricted communications availability for periods more than one month
- Intact physical infrastructure; however, roadways are likely to be fully or partially blocked with out-of-service vehicles
- Evacuations, including unplanned evacuations, are highly likely
- Transportation control systems are greatly impacted to the point of extended failure
- EOCs (if activated) will function at significantly lower levels
- Most transportation vehicles are out of service or stranded
- Federal response protocol may be delayed greater than one month
- Critical first responder and Disaster Service Worker personnel shortages exist due to transportation network outages
- US DOT's Maritime Administration may designate certain ports, or portions of ports to reserve capacity to handle emergency DoD and selected logistics needs using Port Planning Orders[10]
- Public Information efforts will be fragmented, and critical information may not get to the public in a timely fashion

High-priority logistics and transportation needs post-EMP would include:

- Staging Areas
- Distribution Points (PODs)
- Storage and Warehousing
- Material Handling Equipment
- Security
- Labor

[5] Metropolitan Transportation Commission. May 2008. *Regional Transportation Emergency Management Plan*. Baseline Operating Plan. https://mtc.ca.gov/sites/default/files/FINAL_RTEMP_May_2008.pdf . Accessed on March 25, 2018.

[6] "Acts of War" are not further defined.

[7] CA Governor's Office of Emergency Services et al. March 2008. *Regional Emergency Coordination Plan (RECP) - Base*. http://bayareauasi.org/sites/default/files/resources/RECP_BASE_PLAN.pdf . Accessed on March 25, 2018.

[8] CA Governor's Office of Emergency Services et al. March 2008. *RECP Logistics Subsidiary Plan*. http://bayareauasi.org/sites/default/files/resources/RECP%2520Logistics%2520Subsidiary%2520Plan.pdf. Accessed on March 27, 2018.

[9] CA Governor's Office of Emergency Services et al. March 2008. *RECP Transportation Subsidiary Plan*. http://bayareauasi.org/sites/default/files/resources/RECP%2520Transportation%2520Subsidiary%2520Plan.pdf. Accessed on March 27, 2018.

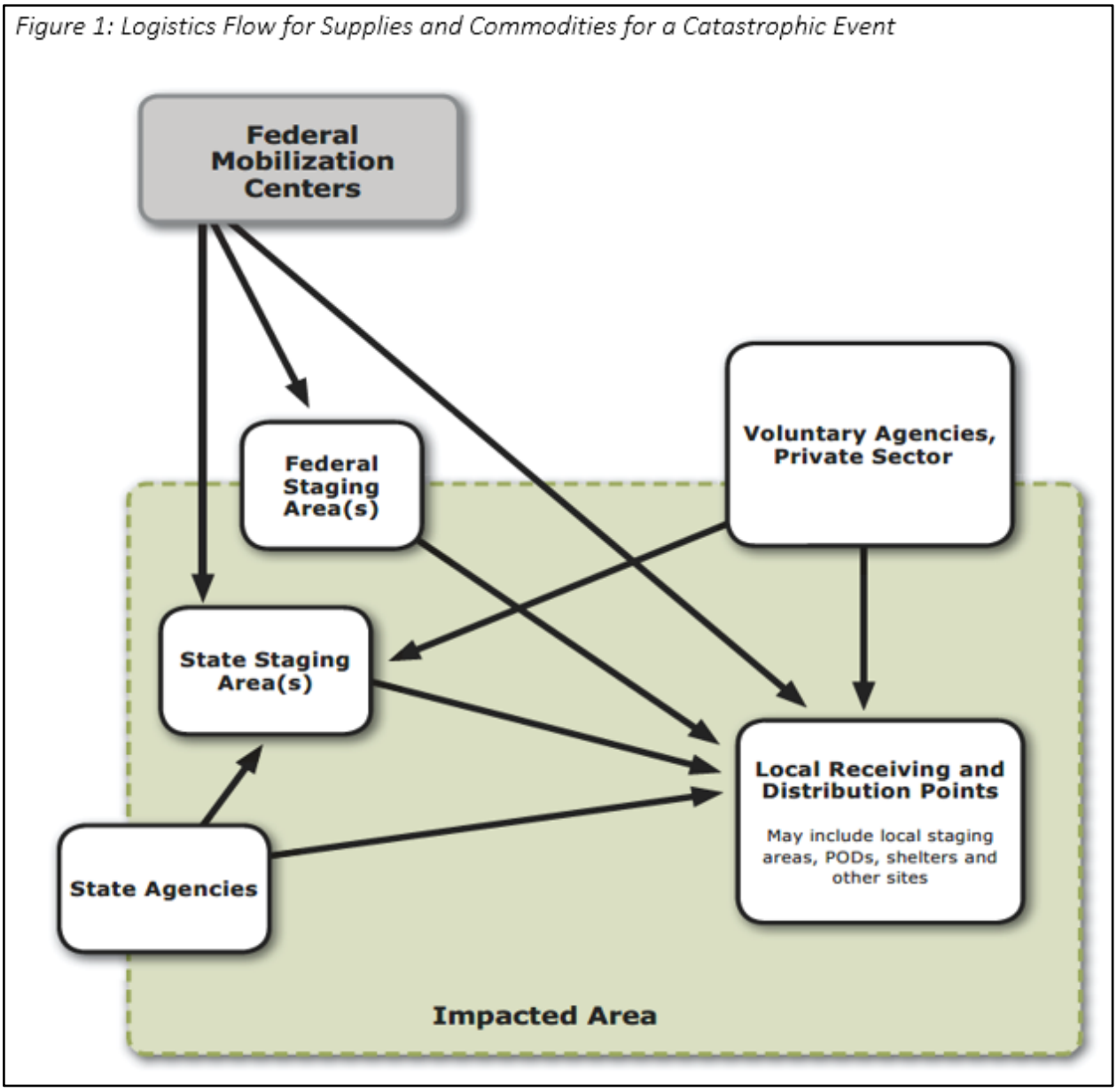
[10] Title 46 CFR Part 340.

- Trucks and other cargo-carrying vehicles
- Identification of suitable logistics facilities such as parks, warehouses, schools, gymnasiums, fairgrounds, armories, military bases

Assets to be considered in the post-EMP transportation planning effort:

- Strategic National Stockpile
- Strategic Petroleum Reserve
- Military Bases and supporting equipment

Figure 1: Logistics Flow for Supplies and Commodities for a Catastrophic Event



- American Red Cross and other voluntary (VOAD[11]) infrastructure

Post-EMP Logistics

Logistics facilities that can be considered are listed below and their relationship is illustrated in Figure 1. Note that each arrow represents a transportation resource requirement. [12]

FEMA Logistics Centers: Permanent facilities that receive, store, ship, and recover disaster commodities and equipment. In the continental United States, there are four facilities containing general commodities. There are also two facilities containing special products, computers, electronic equipment, and medical and pharmaceutical caches. Consideration must be given to sustainability of these assets for periods exceeding one month.

Commercial storage sites: Permanent facilities owned and operated by private industry that store commodities for FEMA, such as freezer space for ice.

Other federal agency sites: Other Federal agencies with responsibilities under the NRF may mobilize commodities from their respective logistics centers or vendors.

Federal Mobilization Centers: Temporary Federal facilities outside of the incident area at which commodities, equipment and personnel can be received from Logistics Centers, other Federal agencies, and vendors and pre-positioned for deployment as required. These commodities remain under the control of the National Response Coordination Center until deployment to the affected area is required. Currently these centers are generally projected to hold three days of commodities. This planning factor must be lengthened to periods exceeding one month which will require a sustainability plan and marshaling of an emergency supply chain.

Federal Staging Areas: Temporary facilities near the incident area at which commodities, equipment and personnel are received and pre-positioned for deployment to Federal, state, and local receiving points within the incident area. These commodities are initially under the control of the Regional Response Coordination Center (RRCC) and then the Joint Field Office (JFO). Federal staging areas are generally projected to hold one to two days of commodities. As with Federal Mobilization Centers, this factor is insufficient for an extended grid outage and will require additional planning considerations including emergency supply chain operations. Both federal mobilization and staging areas should be planned for location on existing military bases or other suitable federal facilities.

Emerging Technology in Post-EMP Recovery: A Case Study

One potentially useful emerging technology is Blockchains - an advanced form of electronic transaction processing. Blockchains can be used in a variety of business-related Use Cases including emergency supply chain management. So how does the Blockchain process work in the

[11] Voluntary Organizations Active in Disasters (VOAD). For national VOAD members see https://www.nvoad.org/voad-members/.

[12] *RECP Logistics Subsidiary Plan*.

emergency supply chain management context?

- Blockchain, an immutable, security rich, transparent, shared and distributed, and authenticated network, provides each participant end-to-end visibility based on their level of permission.
- Each participant in a supply chain ecosystem can view both site-specific inventory and the progress of goods through the supply chain, understanding where a container is in transit. They can also see the status of customs documents, bills of lading and other similar data.
- Detailed visibility of the container's progress through the supply chain is enhanced with the real time exchange of original supply chain events and documents.
- No one party can modify, delete or even append any record without the consensus from others on the network.

How these functions might look in an emergency supply chain operation is illustrated in Figure 2. This level of transparency helps reduce fraud and errors, reduce the time products spend in the transit and shipping process, improve inventory management and ultimately reduce waste and cost. These are all important characteristics for an emergency supply chain management system.

By improving visibility, blockchain has the potential to transform entire ecosystems. Supply Chain Management is an ecosystem. Supply chains are prime examples of blockchain's potential for transformation that spans industries. Initial blockchain efforts could have quick impact by transforming even a small portion of the supply chain, such as the information used during importing of supplies provided from OCONUS sources. If key emergency supply chain participants could exchange legal, financial, cargo manifest and inventory documents more transparently and securely, critical supplies could then be routed more efficiently, thus reducing the stress on scarce shipper resources. Blockchain technology could make appropriate data visible in near real-time (for example, the departure time and weight of shipping containers) without sharing sensitive information such as the owners or value of the cargo. Costly delays and losses of critical emergency supplies would be minimized.[13]

On a grander scale, blockchains could enable a robust and secure exchange for shared logistics, coordinating a vast array of activities from sharing spare space in a warehouse to optimizing truck fleets and shipping containers. Supply movements could be more efficiently programmed to minimize the load on post-EMP/GMD depleted transportation resources. Emergency managers could greatly improve demand forecasting and stock replenishment for emergency supplies. Financial institutions, armed with a detailed track record of a supplier's reliability, could extend much needed credit to facilitate payment for emergency supplies.[14] In a national or global emergency, the "swapping" of commodity futures via auctions or via rationing could

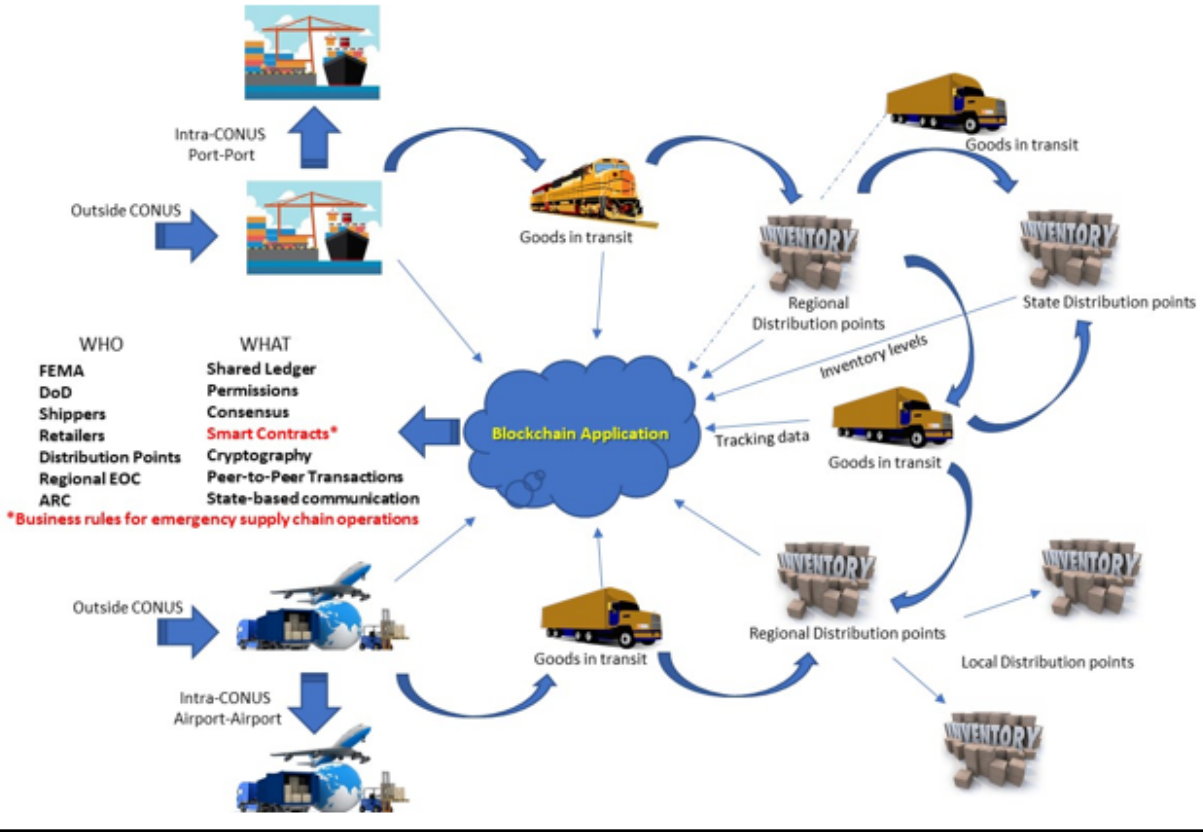
[13] Adapted from: Manav Gupta. 2017. *Blockchain for Dummies: IBM Limited Edition*, Pp 24. John Wiley & Sons, Hoboken NJ.

[14] Ibid.

reduce the time, distance, and energy expended for critical transport. Blockchain resiliency, if promptly recoverable, might reduce overall supply chain burdens and save both life and property in an extended supply chain emergency.

accelerate supply chain recovery. A national effort is called for that would define the supply chain for national recovery efforts (including potential OCONUS assets), who can access the trusted shared network and what access permissions are appropriate,

Figure 2: Conceptual View of an Emergency Supply Chain Blockchain Operation



There would be of course limitations to the use of this technology in a post-EMP/GMD environment. The very technologies upon which Blockchain depends (Internet, IT systems and communications) may be severely degraded. Protection of key data centers and cloud computing interoperability may or may not be feasible. Potential use of Blockchain should be carefully studied at the national and cross-continental levels; it may be that an emergency Blockchain system with alternate communications and backup power are required, and essential to

what business rules will govern contractual processing and the needed structure for a shared ledger application. Other design considerations which go beyond the scope of this paper would also need to be defined.

The Role of Communities in Planning and Recovery

Communities are groups that share goals, values, and institutions. They are not always bound by geographic boundaries or political divisions. Instead, they may be faith-based organizations, neighborhood partnerships,

advocacy groups, hospitals, academic institutions, social and community groups, and associations. Communities bring people together in different ways for different reasons, but each provides opportunities for sharing information and promoting collective action. Engaging these groups in preparedness efforts, particularly at the local and state levels, is important to identifying their needs and taking advantage of their potential contributions. Communities with transportation assets of any kind should inform local emergency managers of commodities and transportation assets available to the region. If local jurisdictions cannot maintain continuity of operations, communities are then elevated in importance. As with any other major disaster, resilience starts at the lowest possible level and must be matched by an adequate and pre-planned top-down response from the federal, state and regional government agencies.

The Role of InfraGard in Planning and Recovery

Where can InfraGard resources and subject matter expertise contribute most to pre-event preparedness? And where does InfraGard fit into the recovery of the nation's transportation system post-EMP? The answer to both these questions lies in the InfraGard Sector Program. The strengths of the InfraGard program – a vetted membership, subject matter expertise across all PPD-21 critical infrastructure sectors and the ability to organize and share information to meet regional needs can be harnessed to better inform the pre-event planning process. Sector Chiefs at the local/regional level are the experts in their critical infrastructure – the components, the vulnerabilities and consequence management. The FBI and its law enforcement partners are the threat experts. The unique partnership between the FBI and critical infrastructure owner-operators allows two-way information sharing that provides the greatest visibility into problem-solution sets. This visibility will better inform local exercise events, infrastructure-specific education and regional planning for both preparedness and recovery operations. Specifically, Transportation Sector Chiefs can be expected to contribute to emergency transportation planning by knowing their modal strengths, weaknesses and potential contributions to regional recovery experts. They can be expected to know key personnel within their modal organizations and how to marshal the surviving resources (vehicles, control systems and personnel.

Summary

The Transportation Sector is large and complex. It crosses jurisdictional boundaries and uses many modes to accomplish the movement of vehicles, cargo and people. Although the physical elements of the nation's transportation system will likely survive an EMP or GMD event, many critical elements of modal control systems likely will not. The ability of certain types of vehicles to survive such an event is largely unknown with the current state of knowledge. Regardless of the post-event condition of the transportation system, critical missions must be supported, even under degraded conditions. First responders must save lives and prevent further damage. The electrical grid must be reconstituted as rapidly as practicable. Critical food, medical and water

supplies must reach the population and critical personnel must get to where they are needed most. The key to achieving a high degree of transportation network resiliency is regional planning. The regional plans will work best if there is a degree of interoperability in their format and content. The San Francisco Bay Area has developed a good model for regional emergency transportation planning. However, post EMP-GMD event assumptions need to be carefully thought out and not underestimated, lest our planning falls short of requirements. Emerging technologies such as Blockchain supply chain management can help us move critical supplies more efficiently with scarce resources, but we may need to define a specific emergency implementation of this technology. This will be a national effort, likely with FEMA leadership. Planning efforts are also important at the community level as recovery and resilience must start from the bottom up in concert with top-down federal and state planning. A generally solid assumption is that federal assistance will not likely be forthcoming for possibly weeks after a catastrophic EMP or GMD event.

The FBI's InfraGard Program does not offer a panacea for EMP-GMD challenges, but it does offer a unique partnership that encapsulates local and regional subject matter expertise, regional and cross-sector information sharing and vetted membership within a dedicated volunteer organization committed to regional resilience.