Supply Chain Threats and Emergency Management

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Introduction

This paper discusses environmental threats to supply chains and how to deal with them. In particular, impacts on infrastructure are outlined. In order to prepare for and attempt to mitigate these threats a basic outline for emergency management is provided. In fact, there are two rival approaches to emergency management. One is proactive and the other is reactive. Tensions between the two will be discussed from a logistics perspective. As well, a hybrid approach which is being used successfully in Alaska will be recommended. However, to complicate matters there is also inter-governmental tensions involved in emergency management. The interplay between the Federal Emergency Management Agency (FEMA) and U.S. state/local authorities will be discussed in order to illustrate this problem. Logistics will be shown to be a critical element in any effective emergency management plan. Restoring law and order, ensuring safety and security are paramount; but these are strategic goals. The tactics are where the complexities of emergency management present themselves. The hybrid approach will be shown to be an appropriate response since it is more flexible and inclusive.

Environmental and Infrastructure Threats to Supply Chains

Weather Vulnerabilities

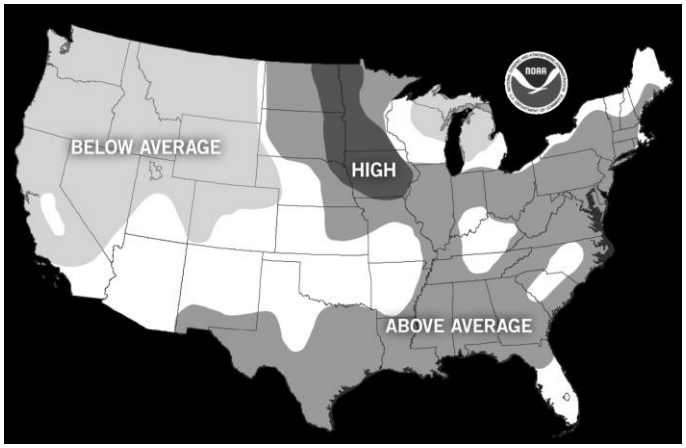
Supply chains are spread out over land, water, and air. Logistical flows must traverse topographical spaces. Therefore, these activities are vulnerable to the forces of nature and unpredictable acts of God.[1] All business activities are dependent on the natural environment in which they take place.

Floods can happen in all 50 of the United States and it does not take much water on the ground before damage becomes significant. Just a few inches can cause property damage while just a couple of feet can wash away automobiles. **Figure 1** shows the extent of the flood risk in the United States for 2010. The map reflected an El Nino effect in the south and East Coast as well as an above average snowpack in the upper Midwest. The NOAA website provides an up-to-date detailed map on changing flood risks as well as other natural hazards which are discussed in this section.[2]

Floods can be by-products of hurricanes which are seasonal phenomena (around June through November in the United States) and can hit coastal states from the Gulf of Mexico northward to New England. Not only is most of the country's populace concentrated along the vulnerable East Coast but some of the most complex and expensive business activities are located there (for example, the dozens of crude oil platforms along the Gulf of Mexico coast and miles offshore). By contrast, the entire West Coast from the Aleutian Islands in Alaska southward to Mexico are vulnerable to earthquakes. Unlike hurricanes earthquakes arrive with little warning, can damage any anchored structure, and can cause tsunamis when the epicentres are situated near shore or offshore. **Figure 2** shows where the risks are highest.

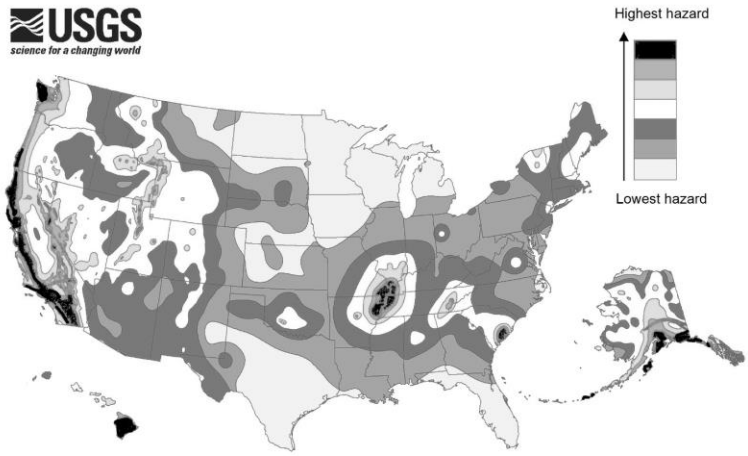
The Midwest from Texas northward to South Dakota are vulnerable to tornadoes. While not as sudden as earthquakes, and yet not as predictable and slow moving as hurricanes, tornadoes are a function of storm systems caused by the mixing of cold and warm air masses along the Prairies. The very strong winds of a tornado can create damage along the same lines as hurricanes except that there is little or no strong rain accompanying. **Figure 3** shows where tornadoes are situated.

Figure 1: Flood Vulnerability (2010)



Source: National Oceanic and Atmospheric Administration (NOAA). U.S. Department of Commerce.

Figure 2: Earthquake Vulnerability (2014)



Source: U.S. Geological Survey. Earthquake Hazards Program.

Seasonal extremes can lead to a destructive chain of events as well. Hot, dry summers can trigger wildfires in forested or even shrubby areas. These summers can also cause droughts. On the other hand, snowy winters can lead to flooding in the spring. Thunderstorms can bring about lightning strikes which can cause fires on the ground or aircraft failures in the sky. They can also cause hail damage to fixed structures and vehicles. Finally, leaving aside whether or not humans are a major cause of climate change, the apparent long-term cycle of climate change represents another challenge. Coastal erosion, disappearing wetlands, Arctic ice melt, and increased acidity in ocean waters will have effects on fish, shell fish, and plants. Warmer temperatures will affect crop cycles and alter the distribution of arable land across the world.

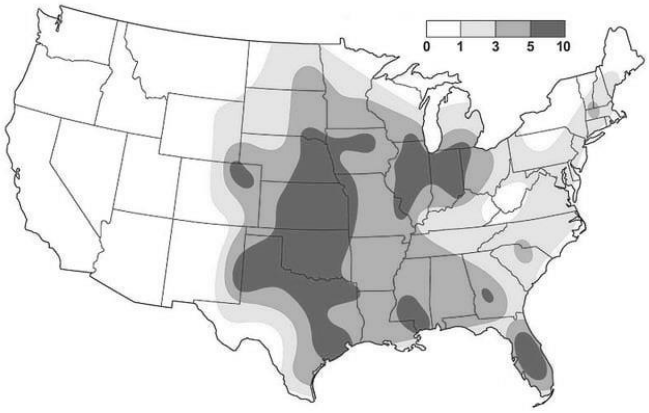
All of these vulnerabilities make it imperative for supply chain partners to maintain emergency management plans on top of the services federal, state, and local governments may provide in times of emergency.

Infrastructure Vulnerabilities

Man-made structures are vulnerable to the weather conditions noted above. They are also vulnerable to simple wear and tear and to inferior design. Wiring problems can lead to fires. Excess water can cause

dams to fail causing flooding. Improper maintenance can cause nuclear power plants to meltdown. Careless transportation of hazardous material can lead to environmental spillage. An overloaded power grid can cause blackouts over wide ranging areas.

Figure 3: Annual Tornado Reports per 10,000 square miles (1950-1995)



Source: National Oceanic and Atmospheric Administration (NOAA). U.S. Department of Commerce.

While government regulation and insurance can mitigate some of the infrastructure risk and risk-taking that private sector organizations might tolerate, the status of the public infrastructure is a different matter. In this case, risk-tolerance and conditions are matters of politics; that is, the amount of taxes the public will tolerate and how much of it they wish to see devoted to maintenance. The public sector saw massive growth in roads, bridges, ports and airports in the decades after World War II. Once built it is a matter of maintaining them. However, fiscal and political realities today have made it progressively harder to generously fund improvement projects.

The Federal Highway Administration collects data on road conditions. For example, in 2013, of the approximately 726,000 miles of road, 74,000 miles were classified as mediocre and 66,000 were classified as poor. Combined, this implies that 19% of the roads are in less than adequate condition.[3] Airport runways are much better with only 17% characterized as fair and 2% as poor.[4] In terms of bridges, about 10% are structurally deficient and 14% are functionally obsolete.[5] These numbers are expected to rise as years pass without adequate infrastructure funding.

Supply Chain Emergency Management Programs: The Basics

Whether it is a private business wishing to enhance security in order to protect its reputation, profits, etc. or it is a government wishing to regulate the security programs of a private business, it is fairly straightforward to outline what a basic security plan should look like.

- Define the activity. The item, the storage, the transport, the names, and locales of the parties involved. All parties along the supply chain should have a hand in building the plan in order to secure buy-in.
- Define the threats. Mitigation/reaction to a security breach is easier when one knows what to expect.
- All those handling the items in storage or in transport should be properly licensed and have proper levels of training and experience. Proper identification must always be carried and numerously checked.
- Access to items in storage or in transport should be limited only to what is necessary to perform the job.
- Incoming cargo must be screened for security before arrival using a protocol. This should include a protocol for the possibility of physical inspection of any damaged cargo before departure or at arrival.
- Outgoing cargo contents should be validated for accuracy of the transaction (i.e., price, quantity, quality, and documents).

- Locks, seals, and some form of tracking program should be in place while the items are in transport. Items in storage need to be within a secured facility.
- Data related to the items above should be gathered.
- Performance should be measured against best practices.
- Risk should be mitigated by performing regular audits, practice drills, and having random inspections.
- Develop relationships with local, state, and federal law enforcement.

Again, these are just the basics and do not imply that a cookie-cutter approach can be taken when it comes to emergency management. Customization is necessary. Complexities in these plans occur when we differentiate among shipment types, modes of transport, vendors, and ports of entry. Another source of complexity occurs because different arms of the government may require different sets of regulations to comply with. As well, the amount of data gathered could be enormous depending upon the volume of activity. Making sense of all the data, let alone making decisions based on it, can be challenging. But what is necessary is to have a basic plan that requires training, documentation, and tracking. If a breach in security does occur the plan has to have response mechanisms in place and protocols for post-breach investigations. Finally, the plan must be re-evaluated to see what can be learned from the breach.

Emergency Relief Programs: The Basics

Short of fighting war a government's role in society is never tested as hard as when it is responsible for emergency relief. Since most natural disasters are unpredictable, because nature itself is unpredictable, so is the demand for aid with respect to its composition, the volumes of what is needed, and the locations it needs to be sent. Responses also need to be immediate. In commercial supply chain management and logistics management an untimely response can lead to such problems as transportation congestion and lost sales. However, when facing a natural disaster an untimely response leads to loss of life.

In a disaster environment the government must maintain law and order and keep those impacted safe and secure. This should be the government's strategic goal. Those impacted need to be provided with five crucial items: water, food, shelter, medicine, and energy (power). Without any one of these it is hard to imagine law and order being restored in a peaceful way. Therefore, provision of these five items should be part of the government's tactics. Of course, logistics is key to successfully providing any item over some distance and area; and it is especially so if the area has been hit with a disaster of some kind.[6] Logistics is a foundation for the strategy and tactics the government wishes to undertake. The logistics infrastructure itself may be impacted severely by the disaster. The logistics foundation is comprised of three items: information, communication, and transportation. Without any of these items, the coordination and delivery of relief is not possible. Therefore, the government needs to be concerned with the logistics which feed into its humanitarian supply chain. **Figure 4** gives a visual representation of this structure.

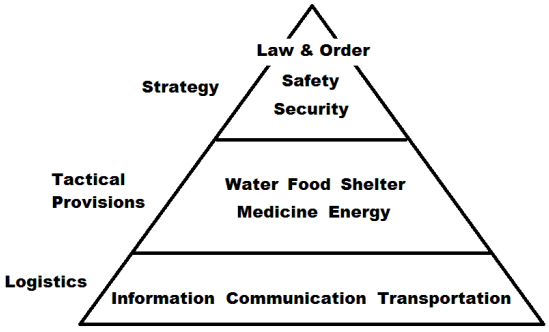
The government's relief plan needs to replace the impacted commercial flow of goods, services, and information until private markets can be restored. In order to get markets working again, people need to have their normal lives restored. Families have to be brought back together; workers need to return to their jobs; and children need to return to school. Such an endeavour requires large scale planning and coordination with many organizations. This is very much an application of supply chain planning and management.

Two Approaches to Planning

If a large scale disaster takes place all eyes turn to the government for assistance, relief, and reconstruction. One approach to meeting the government's goal is to be proactive and plan in advance.

The other is to be reactive with a looser plan which adapts to the specific needs of the situation. From a supply chain and logistics point of view it is possible for either of the two approaches to be successful. The proactive approach requires the right private sector partners and vendors to be in place and able to deal with the disaster in question. They have to be able to broadly deal with the tactical and logistical challenges noted in **figure 4**. The reactive approach, on the other hand, requires the government to know quickly which private sector partners and vendors to tap for the relief effort. More specialized firms may be recruited in this case; but time will be of great essence.

Figure 4: Support Structure for Disaster Relief



There is a certain tension between these two approaches from a logistics point of view. A proactive approach would necessitate staging elements for relief efforts near anticipated impact areas across the country. This is similar to push logistics and buy-to-stock tactics. The reactive approach would hold these elements in reserve and send them out to the impact area once it has been identified. This is similar to pull logistics and buy-to-delivery tactics. John W. Madden, former Director of the Alaska Division of Homeland Security and Emergency Management (DHSEM), sees this as a logistical choice between "just in case" vs. "just in time". However, under his leadership, Alaska adopted a hybrid approach.[7] Why? Since some parts of Alaska do not even have the necessary logistics infrastructure to move to an impacted area (especially in winter months) it was deemed prudent to stage water, durable goods, and fuel at several rural communities. Other less durable relief items would be centrally held and released as needed. The hope would be that the staged items would provide enough immediate relief to hold out for the inbound items. In 2005, Alaska DHSEM formed a public-private partnership (PPP) to help anticipate needs and assist in relief efforts. The Alaska Partnership for Infrastructure Protection (APIP) includes the private owners of key infrastructure in Alaska to work with the Alaska government. Membership is voluntary and the incentive to join is the feeling that the investment of time and energy in helping to plan is exceeded by the mitigation of risk the private sector partners feel they are gaining.

Federal Emergency Management Agency (FEMA)

DHS was formed in the wake of 9/11 in order to bring various government, trade, and security organizations under one roof. The Federal Emergency Management Agency (FEMA) was formed in 1979 with a similar intent--- to bring several emergency preparedness and response organizations under one roof. Communicating with the federal government became so cumbersome that the National Governors Association petitioned the president to consolidate the necessary organizations. These included:

- Defense Civil Preparedness Agency (formerly under the Department of Defense)

- Federal Broadcast System (formerly in the Office of the President)
- Federal Disaster Assistance Administration (formerly under the Department Housing and Urban Development (HUD))
- Federal Insurance Administration (formerly under HUD)
- Federal Preparedness Agency (formerly under the General Services Administration)
- National Fire Prevention Control Administration (formerly under the Department of Commerce)

All natural and man-made disasters would fall under its jurisdiction. Originally, the FEMA director would report directly to the president; however, in 2003 FEMA would be absorbed into DHS and the director now reports to the DHS Secretary. This changed FEMA's primary mission to national security and terrorism from its original "all-hazards" approach.[8]

The biggest challenge FEMA faces is coordination with state and local authorities. This is very much akin to a governmental supply chain problem--- coordinating with one's vendors (i.e., the private sector sources of emergency supplies) and one's customers (i.e., the state/local governments and the civilians impacted). Prominent coordination failures include responses to Hurricane Andrew in Florida and Louisiana (1992) and Hurricane Katrina in Louisiana (2005). The problem is balancing the abilities of the federal government's access to vast supplies with local governments' more intimate knowledge of the needs of the local population. The federal government is burdened with many more regulatory hoops to jump through than local governments. For example, the *Disaster Relief and Emergency Assistance Act* (or Stafford Act, 1988) gives FEMA the power to directly allocate funds to local governments and firms. In reality, however, the federal bureaucracy has made it difficult to put this into practice.[9]

Part of the decision for proactive or reactive planning rests with FEMA's choice of private vendors. It is certainly proactive to have vendors in place and on contract. Contracts could be short-term (such as for bottles of water) or long-term (when reconstruction is necessary). Vendors could be chosen based on competitive bidding in order to keep prices low and allow FEMA to demonstrate fiscal responsibility. Pre-disaster planning is more of a buyer's market; and unlike other agencies FEMA is not required to solicit competitive bids. The challenge, of course, is to anticipate needs correctly. FEMA, however, has tended to use the reactive approach. With prompt response taking precedent over other goals there is the chance for incorrect, insufficient, and over-priced aid being gathered. In an emergency the vendors are in a seller's market. "Use of non-competitive procurement approaches increased at the federal level by 115% from 2000 to 2005, and $8.7 billion was awarded through no-bid contracts for emergency procurement."[10] The value of a hybrid approach is evident when considering local vendors. In a proactive approach it is hard to know which vendors may be able to provide service in the vicinity or region of a disaster. In a reactive approach when a disaster strikes it is even harder to reach out to the available vendors because communication technology may be compromised and, furthermore, there was no coordinating plan put in place for the vendors to respond to. "The Army Corps of Engineers reported receiving over 6,300 phone calls within two weeks after [Hurricane] Katrina landed, many from local and regional contractors who have complained that their calls [to assist in the relief efforts] were ignored."[11] The hybrid approach would substitute pre-approved vendors with local/regional ones if they can demonstrate the ability to provide the necessary services in a timely fashion. Of course, employing vendors as close to the disaster as possible has two desirable effects: (1) it helps to lower transport costs; and (2) locals are helping locals which is necessary in sustaining both the economy and the social fabric.

FEMA's choice of vendors to partner with represents a PPP in order to facilitate humanitarian logistics. The goal is to restore law and order as well as safety and security. The PPP relationship among the partners is not one of regulation or policing. In this way, it is very similar to a standard business-to-

business (B2B) relationship when market forces are driving it. However, as a government entity, FEMA may not feel the pressure that private sector firms do in having to choose appropriate partners (based on, say, cost or quality) and setting up strong contractual relationships. Indeed, the transaction cost approach is noted for the view that contracts can never be written to cover all possible contingencies. This means there is always room for opportunism (or working for self-interested private goals). In the public setting transaction costs may be higher than otherwise.[12]

Vendor partnership with FEMA is voluntary and the vendors expect to be paid (unless they are willing to donate their services). To better gauge PPP structure, consider the seven "best practices" proposed by the National Council for Public-Private Partnerships[13]:

1) Public sector champion
2) Statutory environment
3) Public sector's organized structure
4) Detailed contract (business plan)
5) Clearly defined revenue stream
6) Stakeholder support
7) Pick your partner carefully (not necessarily the lowest bid)

In terms of these seven points the ones which are the most challenging for FEMA are 3), 4), and 7) because they go to the heart of whether or not the contract/plan is based on a proactive, reactive, or hybrid approach. However, once this is decided upon everything else becomes more workable.

Complexity and Risk in the Supply Chain:

Complexity, and the realization that everything cannot be controlled, means that a certain amount of risk in the supply chain must be tolerated. Supply chain risk may be defined as the likelihood that an event with negative consequences will occur. The impact of the event, from a single organization's point of view, depends on where it resides along the supply chain relative to where the event occurred. The shock wave dissipates to some degree as it leaves the epicentre; but the degree depends on the situation. Supply chain risks may be broadly characterized in the following way:

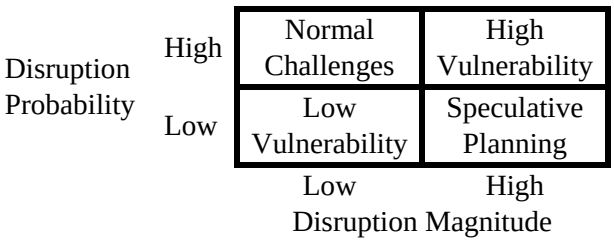
- External and either localized or end-to-end: for example, a power outage at one plant would be local while a terrorist event (even if directed at one plant) can have end-to-end effects. Dependencies along the supply chain determine how the shock wave will ripple along.
- Suppliers: an upstream risk of a slowdown in the receipt of inputs in the production process.
- Distribution: a downstream risk which slows down the process of getting outputs to market. For example, a carrier may not have the capacity to ship.
- Internal: a breakdown in the production process. For example, labor from one area/region not being able to make it to work can shut down a plant in another area/region. Quality control could be a problem.

Of course, the government has an impact as well on these supply chain risks. Political uncertainty, currency fluctuations, and changes in the tax regime can increase external risk along the supply chain. Specific taxes, trade tariffs, and non-tariff barriers can affect the level of risk in dealing with upstream supply and downstream distribution. Internal risk may increase due to wage and price controls, taxes, labor laws, etc. The overall question is: can some of these risks be mitigated? If so, how?

Supply chain management, by necessity, encompasses risk management. If a manager acknowledges that outcomes are subject to variability which can lead to disruption then there is risk. These outcomes are often unplanned and unanticipated. Part of the manager's job would be to help mitigate this risk.

While it is important to take stock of threats the focus must be on the areas at risk. The way to measure risk is to assign a probability to a particular threat. If a dollar value of the consequences of the event is estimated then an expected cost can be assigned. The expected cost should be balanced against the actual cost of mitigation. Naturally, the organization tasked with mitigation would like to see mitigation cost be below the expected cost of the event. A simple key performance indicator (KPI) is the ratio of the cost of mitigation to the expected cost of a successful crime; and this KPI needs to be less than one. Another useful KPI would be "time to recover" from an event. This highlights the opportunity cost of not investing in risk mitigation. During recovery there is a loss in revenue and, potentially, loss of life and brand reputation. The difference in the loss during the recovery time with particular forms of mitigation versus without helps to assess their worth to the organization. Another simple method is to categorize the probability of a supply chain disruption as either high or low and the magnitude of the disruption as either high or low. Possible events would be assigned to one of four cells in **figure 5**:[14]

Figure 5: Vulnerability Matrix



Decisions makers need to focus their attention on the high vulnerability cell. Events in this cell have the highest expected cost to the organization and its supply chain. From a natural disaster perspective the organization would be located in an area prone to earthquakes, tornadoes, hurricanes, etc. and these events should be listed in that cell.

Vulnerability is the mirror image of resiliency; therefore, the low vulnerability cell would include disruptions that the organization can deal with quite effectively through minor adjustments or repairs. From a natural disaster perspective this includes thunderstorm damage, minor flooding, etc. The normal challenges cell represents expected operational challenges that should also be easy to deal with. The best example of these include disruption to infrastructure (e.g., port congestion). As long as other transportation options are available, the resilient organization should have alternative plans in place to detour incoming and outgoing shipments. Finally, the speculative planning cell includes events which are rare but highly impactful (e.g., "known unknowns" and "black swans"). From a natural disaster perspective this would include unseasonable severe weather.

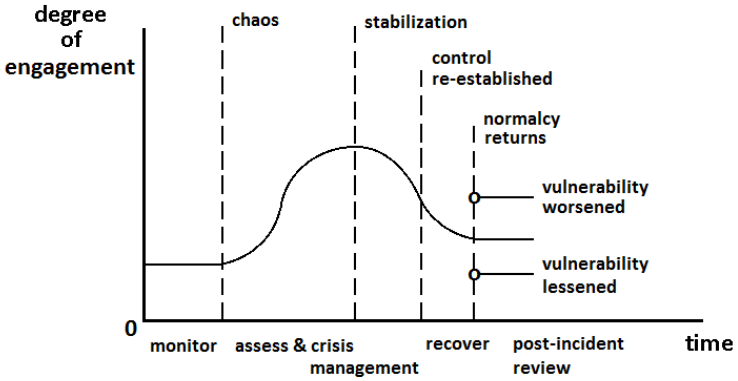
Given the nature of the organization and its supply chain it does not have much control over whether or not an event's disruption magnitude is categorized as low or high. The organization does, however, have control to some degree over the probability of the disruption of some events. For example, using "state-of-the-art" building material can move the incidence of *some* natural disasters from the high vulnerability cell to the speculative planning cell. In this case risk mitigation appears to have worked; but the organization has to make sure to plan for the unlikely event that the system fails. This means building in back-up systems, redundancies, alternative sources and facilities, etc. From a natural disaster perspective a state of the art facility in an earthquake zone may mitigate the damage of low magnitude earthquakes but may not mitigate the worst unless well thought out plans from upstream and downstream supply partners in and outside the impacted area are in place.

Engagement

Organizations should put in place cross-functional teams of experts with representatives as far along the supply chain as they can engage. Not only does this assist with the planning process it also assists with regaining control of the situation when a supply chain disruption occurs.[15] **Figure 6** gives an impression

of the activities along a timeline. The organization starts at time zero with an emergency management plan in place and a degree of engagement with a cross-functional team which it believes is commensurate with the possible disruption. The disruption may or may not occur; but if it does the activities in **figure 6** show a process which needs to be accounted for in the security plan.

Figure 6: Disruption Management Timeline



Assume that after some time of monitoring the situation a disruption occurs. The opening moments are one of chaos which forces the team to accelerate the level of engagement as it tries to assess the situation. Crisis management, which ought to be outlined in the plan, is deployed after the proper assessment has been made. If it is appropriate and mitigating then an inflection point is reached and the engagement begins to peak as the disruption is stabilized. Once the team feels that control has been re-established the process of recovery begins and engagement levels off. Once normal working conditions return it is very important for the team to conduct a comprehensive post-incident review in order to learn from the disruption and how it was responded to.

Naturally, the timeline for these activities is dependent on the type of disruption that has occurred. If it is the case that the disruption is impactful to the point where government intervention is necessary (i.e., it is a wide-ranging disaster) the timeline for chaos and stabilization would expand since multiple supply chains would be affected and the government's response has to be prioritized. Recall **figure 4** and how the government's first task may be to achieve the strategic goals of law and order, public safety, and security. The tactical provision of water, food, shelter, medicine, and energy (power) will take precedence over the restoration of any private supply chains.

Effectiveness vs. Efficiency

Crisis management as depicted in **figure 6** does have a common factor whether the disruption is to a private supply chain or to a wider public area. Assessing the crisis can be messy and chaotic. As such, this shows the effectiveness (as opposed to the efficiency) of the crisis managers. Effectiveness involves getting a handle on the disruption/disaster as fast as possible with as much resources as possible. This "all hands on deck" approach involves such things as: locking down the impacted facility, guarding critical infrastructure, putting out fires, and, above all else, saving lives. This is not a process based on market signals and negotiating. Efficiency, which does require responding to market signals, should only enter into the calculations once normalcy has returned.

The post-incident review may involve improved training, adjusting responsibilities among supply chain partners, and possibly changing partners. The review should develop questions asked and lessons learned. These should be worked into the updated emergency management plan. Once this is done it may or may not be business as usual. There are two possibilities that may arise. The learning and adaptation to the past disruption may indicate that a structural change has occurred in the state of nature for this supply chain. The vulnerability inherent in the organization may be perceived to be permanently higher or lower

and requires the respective change in the degree of engagement. The disruption, in other words, would be a game-changer.

Problems with partnership can be seen in the inter-governmental relations in disaster relief. Recall how FEMA and state/local authorities try to decide between proactive and reactive approaches to disaster relief. Unlike the standard coordination (or "stag hunt") game the two players want to coordinate their efforts but each puts a higher value on different plans. **Figure 7** shows this as a standard "battle of the sexes" game.[16]

Figure 7: Disaster Relief Programs as a Battle of the Sexes

		State/Local Agency: Proactive	State/Local Agency: Reactive
FEMA	Proactive	(10,20)	(0,0)
	Reactive	(0,0)	(20,10)

Payoff Order:
(FEMA, State/Local Agency)

The game is structured with FEMA's preference for reactive planning and state/local agencies preferring proactive planning. However, both players see a lack of coordination as being the least valuable position. If this is the case there will be two Nash equilibria of (proactive, proactive) and (reactive, reactive). Which equilibrium would more likely come about? There are three ways to decide. First, the players could negotiate a binding contract which commits each to a particular planning approach. Second, one of the players simply makes a pre-commitment to one of the two plans. Most likely, the bulk of the political power rests with FEMA. If FEMA pre-commits to a reactive approach, state/local agencies may feel little choice but to coordinate their plans in that fashion. The game would settle on (20,10). Third, the decision is taken out of the two players' hands and turned over to a third party. In this case, a public-private partnership (PPP) like APIP in Alaska could work to get both players on the same page. The PPP would be made up of representatives of all levels of government in order to work to a consensus. In this way, **figure 7** would morph into a pure coordination (or "stag hunt") game which might look like **figure 8**.

Figure 8: Disaster Relief Programs as Pure Coordination

		State/Local Agency: Proactive	State/Local Agency: Reactive
FEMA	Proactive	(30,30)	(0,0)
	Reactive	(0,0)	(10,10)

Payoff Order:
(FEMA, State/Local Agency)

In this example, the PPP feels that the appropriate plan should be proactive. There are still two Nash equilibria but the PPP informs the two players on how to value them. The point is that there is now a Nash equilibrium which is also Pareto optimal. The PPP's hybrid approach is to be more subjective and choose the appropriate style given the situation at hand or what is likely to be at hand.

Sustained partnership is part of the formula for success. It will strengthen the supply chain. Shared intelligence is the raw material necessary to help turn data and facts into information, knowledge, etc. The supply chain needs to become resilient to disruption. This is a matter of effective emergency planning. Logistics needs to have more visibility. This is a matter of real-time tracking, knowing routes, networks, having a chain of custody, etc. Investing in information technology then preparing for the data avalanche is also necessary. This is a matter of overcoming the knowledge management problem of combining technology with employee and supply chain partner buy-in.

Conclusions

Tactics require flexibility. Effective logistics, even under normal business conditions, demands flexibility in order to support the strategic goals of the supply chain partners. In this tension between strategy and tactics, proactive and reactive approaches to emergencies, and inter-governmental rivalries it makes sense to adopt a hybrid approach to emergency management. This paper is an attempt to demonstrate the value in this alternative approach using a logistics perspective. The recognition of complexities, risk mitigation, and partnership-building is fundamental to effective emergency management. Of course, these concepts are quite familiar to practicing logisticians. It makes sense to bring a logistician's eye to the problem.

Notes

[1] Bullock, *et al*. (2013). chp. 3 provides a detailed overview of hazards which can negatively affect the supply chain.

[2] See NOAA's National Weather Service map at: http://www.nws.noaa.gov/view/largemap.php

[3] The measure is called the International Roughness Index (IRI) and a complete state by state breakdown may be found in *State Transportation Statistics.* (2015). table 1-4.

[4] *National Transportation Statistics Annual Report*. (2015). table 1-25.

[5] *State Transportation Statistics.* (2015). table 1-7.

[6] Research in humanitarian logistics includes: Atkinson and Sapat (2012), Matopoulos *et al.* (2014), and Trestrail *et al.* (2009).

[7] See Madden (2014). Alaska is a state which has many vulnerabilities. Large distances over wilderness and mountain ranges are combined with sparse rural infrastructure. This is combined with susceptibility to volcanoes, earthquakes, floods, and, depending on the season, bitter cold and wildfires.

[8] During the Reagan Administration FEMA's mission was changed to a primary focus on nuclear warfare. For a fuller discussion see Bullock *et al*. (2013) pp. 615-16.

[9] Atkinson and Sapat (2012). p. 360.

[10] Atkinson and Sapat (2012). p. 362.

[11] Cray (2005). p. 20.

[12] For the differences in ethics and practice of public and private sector contracting see Hawkins *et al*. (2011) p. 569.

[13] National Council for Public-Private Partnerships. (2016). "7 Keys to Success". Website.

[14] This figure builds on Sheffi and Rice (2005) p. 43.

[15] See Sharma and Vasant (2015) p. 10. The teams and the security plan presuppose cooperation among all the parties. The plan should cover the protection of all supply chain assets against disruptions. This can be handled through designing rules and using appropriate technology in order to prevent disruptions and, if unsuccessful, resume operations within minimal loss.

[16] The game gets its name from the story of a married couple which wants to do things together but the husband most prefers a sports match while the wife prefers the ballet. In the pure coordination, shown in **figure 8**, both the husband and wife would feel the same way about sports and the ballet thus making the joint attendance at the most preferred event Pareto optimal.

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