Agile Emergency Response: A Supply Chain Approach to Evaluating the Efficacy of Emergency Response Efforts in the Wake of Hurricane Katrina

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Abstract

Hurricane Katrina transformed the approach of all levels of coordination in response to large-scale emergency. Failure at all levels of the emergency response hierarchy—and few successes by the private sector—to mitigate the damage of natural disaster offers an opportunity to evaluate what worked and what does not; to revise the primary functional components of the emergency response model, to better suit a favorable outcome. Despite imperfections in the methods implemented to relieve the constraints on the supply chain and logistics functions of emergency response, lessons of the last 5 years since Hurricane Katrina better prepare the United States to respond to future catastrophe. Several potential solutions to critical failures are addressed.

Keywords: emergency response, supply chain management
Introduction

When Hurricane Katrina made landfall on the morning of Monday, August 29, 2005 in southeast Louisiana, it was still uncertain whether the damage would be localized or if the infrastructure of inland urban areas of New Orleans would suffer severely from the ensuing storm surge. Ultimately, the levees that protected New Orleans and surrounding areas failed, some of them within hours of the storm’s move inland. The result was that 80% of the city and significant portions of surrounding parishes were under several feet of water. This condition lasted weeks after the initial storm, and damage was most locally severe along the immediate coastline of Mississippi, Louisiana, Alabama, Florida and Texas.

President George W. Bush on August 27, 2 days before Hurricane Katrina made landfall, declared New Orleans a Disaster Area, which under federal law qualifies the state for Federal Emergency Management Assistance through FEMA and partner agencies in an effort to “alleviate the hardship and suffering caused by the emergency on the local population, and to provide appropriate assistance for required emergency measures “[…to save lives, protect property and public health of safety, and to lessen or avert the threat of a catastrophe…]” (Office of the Press Secretary, 2005). At the same time, the National Guard began to accumulate resources in the regional perimeter to feed the supply chain the necessary human, material and information support necessary in a worst case scenario. The United States Northern Command established a Joint Task Force stationed at Camp Shelby, Mississippi on Sunday, August 28, the day before Hurricane Katrina made landfall. However, despite the early warning to citizens, the declaration of a National Emergency and the allocation of resources to the region days in
advance of landfall of the Category 3 Hurricane, the region was still not prepared to mitigate the devastating effects of the storm on property, infrastructure and general welfare. Problems that were unforeseen included the entrapment of first responders within the disaster area, which resulted in a weakened response human resource network; the disabling of cellular communications networks leading to a breakdown in the process of reuniting families displaced by the storm; and the decision by Mayor Ray Nagin to delay the mandatory evacuation of New Orleans until 19 hours before landfall which resulted in tens of thousands of residents trapped within the confines of the city’s failed levees, crumbled highways and rising waters (United States Congress, 2006, 2). The city’s evacuation plan, though initially praised as evacuating 80% of the metropolitan area’s 1.4 million residents, failed to reach its most vulnerable residents: those without cars and the sick and elderly. (Handfield, 2005).

It is apparent that while the top-down efforts to organize and pre-empt a worst case scenario were implemented with the full capacity of the Department of Defense and its ancillary agencies, there existed a breakdown in the chain of coordination and information sharing between local, state and federal governments. The Full Report by the Bipartisan Committee of the U.S. House of Representatives, adequately titled “A Failure of Initiative, summates the problem with emergency Response to Hurricane Katrina: “If 9/11 was a failure of imagination, then Hurricane Katrina was a failure of initiative. It was a failure of leadership.” (U.S. House Report, February 2006).

Without dispute the level of national emergency caused by natural disasters such as hurricane, earthquake, flood, tornado; as well as terrorism or environmental disasters, strains the capabilities of our supply chain, infrastructure, material, information and
human resources. Considering the inevitable yet highly unpredictable nature of such occurrences (even in the event of unprecedented weather forecasting in the case of Hurricane Katrina, the eventuality of landfall was measured in a few days whereas in private or regular enterprise, forecasting is done in months, years and multi-year outlooks) what common problems can be identified in the supply chain management response to emergencies, and what can be done to remedy these problems? The purpose of this paper is to identify several organizational developments that have resulted from the Katrina disaster, as well as to propose weaknesses that yet exist in the framework for response at the government level as well as at volunteer, enterprise and individual levels. The ultimate purpose of this paper is to show how these developments can aid in the mitigation of future catastrophes of such scale as the Haiti Relief Effort and the Deepwater Horizon Explosion.

The National Response Framework

Prior to Hurricane Katrina, the main article of organization for emergency response was the National Response Plan (NRP) which was implemented in response to the September 11, 2001 terrorist attacks on the United States East Coast. The intent of the plan was to direct the Department of Homeland Security (DHS) in matters pertaining to the management of emergency from the local, to the state, to the Federal level. The general method of emergency response is that local resources must be expended before state resources can be allocated to the respond to disaster, and likewise the state resources before Federal aid. However, under the NRP, the DHS can assume control for the entire emergency response. The DHS invoked the NRP the day after Hurricane Katrina—only
10 months after its creation—and therefore Hurricane Katrina was a full test of the viability of the NRP.

The success and failure of the NRP is evident by the Congressional Testimonies of the Federal Emergency Management Agency (FEMA) in the years following Hurricane Katrina. FEMA underwent a major re-structuring due to the inadequacy with which it managed Emergency Response for Hurricanes of the 2005 season, to the extent that the Post-Katrina Emergency Management Reform Act was passed to ensure appropriate conformance in the re-structuring of the agency, the National Response Plan and the inter-organization of primary and secondary agencies. R. David Paulison, in his address to the U.S House of Representatives on July 31, 2007, states in his report: “the new FEMA is sharpening the agency’s focus on building core competencies in logistics, operational planning, incident management and delivery of disaster assistance.” (Testimony to the U.S. House of Representatives, 2007). The new structure included the development of 11 Regional Coordination offices, all of which are directed by individuals with more than 20 years Emergency Response experience (Testimony, 6).

In addition, in an effort to better understand the breakdown in communications and material supply during recent emergency response efforts, a Gap Analysis was performed to determine the “potential disaster response asset gaps in the critical areas of debris removal, evacuation, sheltering, interim housing, healthcare facilities, commodity distribution, communications and fuel.” This engagement of local information in the FEMA preparation effort was unprecedented. The result was a steady decrease in the initial shortfalls and vulnerabilities identified in areas such as debris removal contracts, transportation contracts, identification of potential shelters and evacuation routes,
indentifying points of distribution, and provision of specific commodities such as tarps, generators and cots. The analysis was aided by modeling coordinated by the DHS Science and Technology Directorate to be adapted to large metropolitan areas, which revised traditional modeling aggregates such as population per square mile by considering the prevalence of high-rise, multi-tenant and mixed-use development in urban areas. This in turn helps to determine the best evacuation routes. The DHS and FEMA further collaborated the evacuation plans of separate states to develop a cohesive evacuation plan that considers adjacent states that may host evacuees” (Testimony, 10).

FEMA also partnered with the Army Corps of Engineers and the Defense Logistics Agency to optimize the planning, ordering, storing and replenishing of certain commodities such as emergency meals and fuel, and develop a roadmap for larger scaled supply chain initiatives, resulting in a reduced acquisition and distribution time, as well as replenishment lead-time.” (13-14).

Another major problem during FEMA response to Hurricane Katrina was the inadequate transparency between agencies regarding the levels of supply warehoused locally and the availability of food, clothing and shelter stockpiles, resulting in the duplicitious procurement by various agencies, including those efforts of non-governmental organizations and volunteer groups. The Total Asset Visibility (TAV) program was developed to coordinate and implement a pilot system to monitor the movement and ordering of commodities, to and from the FEMA logistics centers, select vendors and field sites—with a longer-term goal of intra-agency and external vendors and aid networks. This would result in overall transparency in the levels of critical supplies, allowing for better acquisition of only essential commodities, which reduces spoilage,
wasted overhead, and frees up storage for essential goods at the regional level. The TAV program pushes forward in an effort to position essential supplies within regional reach before disasters occur, which means faster initial response time to incidents. However, TAV required much more development in order to accommodate the range of agencies and partners—both government and non-government—involved in an agile emergency response.

On March 22, 2008, the NRP was replaced by the National Response Framework, which built on the lessons learned in fulfillment of the Post-Katrina Act, and more accurately detailed the inter-involvement of government and non-government agencies in emergency response. One major development over the NRP was that the NRF realized the importance of functional response to catastrophe. The development of Annexes, or protocols for functional responsibility, drilled down to the core competencies required in adequately responding to large scale emergencies. The purchasing and supply management function is most accurately regarded in Emergency Support Function #7: Logistics management and Resource Support to focus “the efforts of all partners and stakeholders of the end-to-end supply chain processes, beginning with planning of customer-driven requirements for materiel and services, delivery to disaster victims as requested by the State or tribe, and ending with replenishment of agency inventories.” (NRF, 25). In an effort to support this protocol, the ESF#7 mobilizes human resources with exceptional supply chain experience to the regional level, from existing Federal resources. The result is a more vetted supply chain management response force, composed of career logistics and supply chain professionals already familiar with Federal agency Standard Operating Procedures (SOP). The result is a synthesis of Federal
procurement experts inter-mixed along the emergency purchasing and supply chain, offering continuity in processes and procedures, while at the same time receptive to local and state needs. This mitigates the bullwhip effect of variability in the supply chain caused by inconsistent operational standards.

Another adaptation of the supply chain management method to Federal emergency response is the push-pull method to the response phase. Immediately before and during the catastrophic incident, the GSA/FEMA/DHS effort focuses on an initial surge strategy, implementing a push-supply method of distribution in order to get essential commodities to regional Mobilization and Resource Centers. Then, after the initial phase of disaster response, the strategy shifts to a pull-demand operation, providing necessary replenishment of food, water, clothing, shelter and other basic needs as infrastructure is restored and private-sector logistics gain functionality. This strategy in unison with the TAV program is strikingly similar to the private-sector continuity plans being developed by companies like Wal-Mart, Proctor & Gamble, and Dow.

NRF ESF#7 does an excellent job of detailing the range of capabilities the GSA in tandem with FEMA and DHS are capable of performing, including:

- Material Management: sourcing, ordering, replenishment, storage and issuing of equipment and supplies including computer, communications and network equipment.
- Facilities Management: location, selection, and acquisition or storage and distribution facilities, including shelter for support personnel.
- Electronic Data Interchange (EDI) Management: including TAV objectives.
- Coordination with internal and external vendors both private and Federal: reviewing best practices for improving delivery of goods and services to the customer.

In conjunction with the other Annexes of the NRF, ESF#7 goes farther to drill down to the core competencies of Federal Emergency Management than any other organizational blueprint to date. Its structure is deliberately transparent so that the NRF can be referenced and modified based on real-time analysis of its implementation, using electronic data management and Internet protocols. As an organizational directive, it not only sufficiently covers the range of potential specialized functions necessary in immediate response to catastrophe; it also implements the full resources of government to alleviate the strain of unprecedented events on any single agency. This offers an ultimate line of support for those rare instances such as Hurricane Katrina, where even the federal government was outmatched for needed immediate resources.

**Commercial Enterprise**

Natural Disaster is costly. For private enterprise, time is of the essence in re-establishing a fully functional purchasing and supply chain, to mitigate the risk of lost stock valuation, reduction in human resources and failing distribution and warehousing networks. Whereas the proof of an effective government emergency response is measured in the general welfare and domestic tranquility of the citizenship, the free-enterprise model requires the utmost in agility, cost-benefit analysis and supply-chain redundancy to mitigate the variability in the daily, seasonal and forecasted supply and demand cycles of business. In order to remain competitive, enterprises dedicate significant resources to evaluating, re-evaluating and modifying their existing purchasing
and supply chains. Therefore, in the occurrence of a natural disaster, it is often private enterprise that is most prepared to navigate the pitfalls of weakened infrastructure and lost revenues.

Proctor and Gamble is one such example of swift and flexible response in time of natural disaster. P&G is responsible for providing for 40% of all coffee consumption in the United States. 20% of that production originates from manufacturing operations in New Orleans, at either of 4 P&G operated facilities, two of which were located in Orleans parish and one of which all access routes were completely blocked by flooding. However, P&G was able to rebound from the effects of Hurricane Katrina by implementing a detailed Business Continuity Plan, which is customized for each facility and rehearsed annually. (Global & Logistics Supply Chain Strategies, Dec 2006).

In anticipation of landfall, P&G transferred backup tapes and data to a command post established 225 miles north of New Orleans, and began accounting for its 550 employees, which were all accounted for by September 19 despite the lack of telecommunications network because P&G established a hotline for inbound calling to trace those individuals which had evacuated prior to the storm. For the employees that were unable to evacuate, P&G was able to secure from FEMA 113 trailers on September 11, and in all over 130 trailers were combined to form an employee village complete with laundry, hot meals and recreation facilities.

In an effort to temporarily transfer operations of the New Orleans facilities, essential operations were relegated to other regional facilities. Functions such as engineering were transferred to Cincinnati; and additional suppliers were sourced in Mexico and stateside to provide coffee while a Kansas City production facility was
cobbled together from used and restored equipment. Because Hurricane Katrina occurred during the fourth quarter of the P&G business cycle—a period where sales of coffee are up 33% over other quarters—the additional demand required an effort to startup local production of the New Orleans facilities as soon as possible.

Seven days after the road access was restored, production began in New Orleans, and by October P&G’s coffee production was back to full capacity, even despite using 80% production employees from non-coffee operations within P&G to allow employees affected by Katrina time to recover. The Business Continuity Plan resulted not only in remarkable efforts to dignify the employees affected by the hurricane; it also resulted in a post-hurricane coffee sales increase of 6%. (Global & Logistics Supply Chain Strategies, Dec 2006).

However, this sort of contingency works better for some products than others. In the case of commodities, Minneapolis grain supplier Cargill chose to wait out the storm and its after-effects. The major buyer of corn, soybeans and wheat from Midwestern farmers uses barges to receive product from up-river and deliver it to processing facilities in New Orleans before it exports the commodities internationally. A cursory study of the alternatives for distribution to another port that does not rest along the barge chain of distribution determined that it would take 15 rail cars and 60 semi-rig trucks to carry the same volume as a single barge (Katz, CFO.com, September 2005). Because the P&G Continuity strategy of re-routing product was not feasible, Cargill chose to allocate its human resources to rebuilding and restoring the local processing facilities.

Perhaps no other corporate entity embodies the agility, tenacity and capability to respond to dramatic inconsistencies in the supply chain than Wal-Mart. The company is
known as not only the largest single corporate entity in the United States by volume. It is also known as the leading supplier of the most basic essentials in time of natural disaster. Wal-Mart deals in sundries, dry goods, and basic needs like clothes, food and toiletries. Because of the extensive reach of the purchasing and supply chain network Wal-Mart has developed to gain efficiencies in delivery, economies of scale and the acclaimed everyday low prices, the company is also in an immediate position to provide assistance in times of emergency response. During Hurricane Katrina, Wal-Mart donated $3 million in non-cash goods donations—which were readily stored in shipping containers before the hurricane made landfall—in addition to $17 million in cash donations to charities. In an effort to support the affected communities of the Gulf States, Wal-Mart ensured their employees were able to get to work by securing fuel lines at local gas stations en route to work. Remarkably, the storm affected Wal-Mart’s retail operations significantly. At the peak of the storm, 126 stores and two distribution centers were closed. Of these closed stores, “more than half ended up losing power, some were flooded, and 89 . . . reported damage.” (Zimmerman and Bauerlein 2005, p. B1) However, within 10 days all but 15 Wal-Mart locations were operational. Both President Aaron Broussard and Sheriff Harry Lee of Jefferson Parish in suburban New Orleans lauded Wal-Mart’s work. In an appearance on Meet the Press, Broussard noted the speed with which Wal-Mart had brought trucks of water to his area and then quoted Lee as saying, “if [the] American government would have responded like Wal-Mart has responded, we wouldn't be in this crisis.” (Meet The Press, 2005).

The ability of a company like Wal-Mart to respond to emergencies of natural disaster relies mainly on the type of product it provides: sundries, general merchandise
and basic goods. These products are distributed along virtual supply chains, which can be revised and re-routed if necessary, rapidly and frequently. For large retailers like Wal-Mart, this means it must maintain a decentralized presence across the United States as its stores generally track the population distribution of the US (Hicks 2007). In addition, big box retailers are also required to penetrate smaller communities to secure market reach. Whereas FEMA must operate on a regional level, private enterprise like Wal-Mart offers an opportunity to access a supply chain network that reaches the customer quicker. And whereas private enterprise is free of the constraints of answering to the public for their actions, Federal government must be more risk adverse. A study conducted by identified by Sobel and Leeson (2006a, pp. 6-7) finds that government agencies have an incentive to avoid “Type 1” errors (errors of commission) and therefore are more likely to make “Type 2” errors (errors of omission). That is, government agencies are likely to apply more conservative strategies than less cautious ones, even if the net benefit is less. Exercising caution can contribute to inaction and delay in response; this may explain why by Wednesday, August 24, five days ahead of Katrina’s eventual landfall on the Gulf Coast, the Wal-Mart command center had gone into planning mode, and two days later, when Katrina struck Florida, the complement of personnel in the command center was over 50 (Zimmerman and Bauerlein 2005).

The key to agile private enterprise response to supply chain disruption is the Business Continuity Plan, which has gained precedence in the past 10 years due to the exponentially increasing cost of large-scale catastrophe. The framework for business continuity takes a 4-step approach to mitigating supply chain disruption: Creating Awareness, Prevention, Remediation and Knowledge Management. And companies like
P&G and Wal-Mart have done an excellent job of recognizing their exposure to risk of supply chain disruptions at multiple levels of management as well as pushing this awareness out to customers and suppliers. By identifying risks, evaluating their prevalence, developing unique strategies for each probable risk—and then using feedback from the supply chain to determine how these risks might affect the economic environment, supply markets, or the capabilities of individual suppliers—private enterprise is able to use real-time changes and standard aggregation of data to determine the most appropriate response for a range of scenarios (both in terms of cost, time and geography). This effort coupled with remediation efforts, where resources are stored and redundancies are secured in order to shore up any disruptions that cannot be accounted by modeling, creates a safety protocol that considers all stages of business interruption. By the constant adoption of new lessons learned, knowledge management creates a reference to right and wrong actions taken in the remediation and recovery phases of supply chain disruption. By applying the lessons learned in the constant revision of the BCP, enterprise can remain well-suited to mitigating the risk of supply chain disruption. (Zsidisin, 2003).

Healthcare

Other sectors of the economy, such as healthcare, are not as adequately outfitted to recover from failures of infrastructure. The loss of backup electrical power generation in New Orleans Hospitals resulted in the death of patients requiring critical care. Charity Hospital, Louisiana’s largest healthcare facility, was left without power for 5 days, in 100 degree heat, and with little food and water. Due to power outages most critical life-support services such as dialysis and respiration were performed manually or not at all.
In addition, nearly all hospitals in the area faced security risk due to looting and potential theft of hospital supplies and pharmaceuticals. (Deboisblacn B. 2005). “At every [hospital], there are reports that as the helicopters come in people are shooting at them,” confirmed Coast Guard Lt. Cmdr. Cheri Ben-Iesan, spokesman at the city emergency operations center. (AP, September 1, 2005). Non-existent or poorly planned backup communications systems resulted in miscommunication of patient recovery locations, and both satellite and cellular service was poorly supplied. In addition, because of the breach in communication and the lack of prior emergency planning, there was no chain of command for whom to call for recovery assistance, and now rehearsed procedure for cooperating with local and federal agencies in evacuating critical care patients to other facilities, as well as supplying triage facilities with needed medical provisions. Roy Alson, MD, Commander of DMAT North Carolina-1, testified to Congress that many problems DMATs had in the field during Hurricane Katrina stemmed from the basic lack of a DHS medical logistics support system to coordinate the transport and placement of NDMS assets. Dr. Alson pointed out that in the three DMAT deployments prior to Katrina, the Federal Emergency Management Agency (FEMA) had failed to deliver medical supplies to the teams in a timely manner. (NPR September 8, 2005). In addition, internal miscommunication between federal agencies resulted in one mobile DMAT hospital that had been developed through the Office of Homeland Security after September 11, 2001, with 113 beds, digital radiology, satellite internet, ultrasound, and a full pharmacy with 100 surgeons and paramedics, was stranded for days outside of New Orleans with no authorization to deploy anywhere in the city. (Liebert, 2006).
Despite the large-scale severity of Hurricane Katrina, Federal health services were well aware of the potential failure of the healthcare systems in areas affected by natural disaster, as early as 2003. A GAO report on hospital bioterrorism preparedness found that when faced with pneumonic plague—an infection that if left untreated has a mortality of nearly 100 percent—and a demand to administer antibiotics within the first 24 hours, there existed serious weaknesses in the medical response system. Three days after the simulated release of the disease, 500 people were symptomatic, and there was scarcity of ventilators and antibiotics. Two days later, 800 cases were reported and 100 fatalities. After one week in the simulation, 2700 cases of infection were reported, and deaths were in the range of 950-2000. The failure to contain the spread of infection was attributed to the lack of medical supplies. Half of the hospitals in the study reported fewer than six ventilators per 100 staffed beds. (Dimitruk, 2005). As of 2004, according to testimony before the House of Representatives, most states have not developed plans to access the stockpile of medical supplies at regional warehouses. Even fewer—about 33 percent—have outlined channels of distribution for the medical stockpile. The failure to implement the findings of these studies before the occurrence of Hurricane Katrina is a failure in the federal and non-governmental healthcare agencies that is simply not tolerated in the standard supply chain model of private enterprise. Because of the specialized nature of most medical implements and healthcare machinery, this creates a difficult scenario that will require a network of interdependence between private and government entities to fully mitigate the risk.

Non-Government Organizations
Since World War II the humanitarian relief community has grown rapidly to include agencies at the highest echelons of multilateral organizations. The United Nations High Commission for Refugees is one such organization that is supported entirely by voluntary contributions that include both government aid and the support of Non-Government Organizations (NGO). However, despite global organization to spearhead response, the actual humanitarian relief supply chain is unstable, due to the fluctuation of the “donor industry”, the convenience of military and political agendas, and the competitive nature of fund-raising that may misappropriate goods and services within an affected disaster area. (Ebersole, 1995, Olorunta and Gray, 2002; Bennet and Daniel, 2002). The result may be a frequent lack of planning in the humanitarian supply chain resulting in inefficiencies such as the overuse of expensive and unsafe transport, failure to pre-inventory stock requirements, and a piecemeal system of inter-organizational communications. (Long, 1997). Because most NGOs take responsibility for the portion of the supply chain closest to the customer, they are often tasked with administering supplies, and are rooted in the affected community closest to the sources of demand. This allows NGOs to have an embedded knowledge of real needs, as well as the best network of local contacts to mitigate the frayed communications infrastructure. However, because most NGOs operate in an evolutionary role within each isolated incident, their supply chain management approach is transitory, and extremely short-term, with each humanitarian effort requiring a completely new supply chain. (McEntire, 1999) In addition, whereas the commercial supply chain is intended to serve the end-user, the customer, through the process of commercial transaction, in the case of NGO humanitarian aid, the customer is often the donor, to which the organization is ultimately
accountable for the allocation of resources. (Oloruntoba and Gray, 2006.) It is possible that a NGO may forego the necessity of a developed logistics network and the use of longer-term implementation such as forklifts, in an effort to supply immediate medical aid and food to refugees, despite the benefit of rebuilding the supply chain. (Byman, 2000).

**Methods to Mitigate Problems in the Emergency Response Supply Chain**

**The Push-Pull Hybrid Supply Chain**

One method to mitigate the variability in the humanitarian supply chain is to use the push-pull hybrid supply chain strategy of determining the decoupling point where a product in a supply chain ceases to be forecast-based and becomes a specific customer order. (Van Hoeck, 1997). This is the point where market pull meets upstream push. There is a two-front decoupling in the sense of strategic inventory stored as far downstream in the supply chain as possible, and the exchange up the supply chain of demand information with which orders, and the needs of the end-user are fulfilled. In application to the humanitarian supply chain model, the emphasis is on lean upstream activity such as remote demand forecasting, mobilization, financing, procurement, transportation and planning. This contravenes the conventional model of NGO emergency response because humanitarian aid is often praised for its agility in responding immediately with donations and human resources. However, if more focus is placed on the establishment of pre-positioning of resources as opposed to the acquisition of additional resources, the supply chain is better prepared to receive donations, in the right proportions, with less waste. Postponement, on the contrary, is the effort of delaying the distribution of goods until more accurate information travels up the supply
chain, (Bowersox and Closs, 1996) making better use of available resources which are treated as strategic inventory. These inventories can be better distributed in response to the actual needs of end users. The combination of pre-positioning generic necessities based on the modeling of various possible disaster scenarios, with the effective postponement strategy to allow for accurate ordering information, creates a reduction of strain on the transportation networks that are so often devastated by catastrophe. By placing generic goods within immediate reach of the end-user, the push-pull hybrid model of humanitarian supply chain management creates a so-called “feed-forward mechanism”. (Chandra and Kumar, 2001).

**Robust Information Exchange**

Another critical application of logistics occurs within the exchange of information along the impromptu communications network that develops during emergency response. Information structures that are common during pre-surveillance phase of emergency response undergo a dramatic expansion as the emergency occurs. Such factors as disorder in the initial response phase, as well as the abridged decisional time-frame in getting accurate information relayed to key decision makers, can have tragic consequences if not addressed early in the emergency response process. With the increase in the number of agencies that interact comes the prevalence of informal information sharing, which creates “noise” in the communications chain, and often results in confusion or inaction. Burton and Ipe define three conditions that impact the development of information structures during emergency response: information relevance, information value, and information availability. (Burton and Ipe, 2007).

Relevance in the information supply chain includes the forecasting of generic goods pre-
positioned based on probable geographical disaster scenarios, with each region requiring a customized set of necessary goods. Inadequate information works in hand with inadequate supply ordering, and causes waste along the supply chain due to un-needed supplies that take up inventory space. Information value also contributes to the timeliness and efficacy of emergency response, because it is measured in terms of specificity. For example, information that has high specificity usually has a narrow window of application, and the limited time window results in the rapid loss of value of highly specific information. (Burton and Ipe, 2007). Finally, the inconsistency with which information is made available to all levels, agencies and organizations, whose actions implicate the abilities of each other, must be mitigated by a constant diligence to standardize, share and validate accurate surveillance information. Imperfect information is caused when accurate information is not captured in surveillance, and then is shared inequitably to parties, or information is willfully hid causing information of questionable quality. (Burton and Ipe, 2007). By standardizing the mode of communications among all information intermediaries, constantly referring to the evaluators of information value, availability and relevance, better decisions are made in less time, targeting a more accurate crisis response.

**Restoring Transport Channels**

The basic function of the infrastructures is to transfer resources from the locations where the resources are produced to the location where the resources are accumulated or utilized. Beyond the pre-positioned goods, all other resources are geographically distant to the affected disaster area. Therefore the adequate management of distribution channels interim to the recovery of roads, ports and railways disrupted by natural disasters is
critical. Giovinazzi and Nicholson show that most planning for transportation channel disruption is done in terms of debris blocking safe passage, and not in terms of structural or geotechnical hazards such as future seismic occurrence or weakened structure adjacent cleared roads and the secondary affect on neighboring architecture. In addition, while geotechnical hazards are considered, they are only considered in terms of the supply chain transportation channel being either “open” or “closed” and not the degree to which the channel is functional. The lack of specificity results in sub-optimal intermediate transportation channels, because even a small reduction in channel capacity, the channel is determined “closed”, can result in substantial disruption of transport system performance. Modeling the development of an origin-destination trip matrix for a geographic zone, considering levels of functionality along each trip-path, can factor for traffic volume, travel times and accessibility as well as the benefits gained from reducing choke points. The result of such modeling can determine the most immediate allocation of resources for debris collection along channels that promote the greatest gains in freedom of movement.

Considerations for Current and Future Emergency Response

Haiti Earthquake

In the aftermath of the January 7.0 magnitude earthquake that disrupted Haiti with an epicenter just south of the capital Port-au-Prince, the immediate need was for medical supplies and water followed by debris removal. The fact that the greatest source of income for Haiti before the earthquake was from foreign aid indicates the impoverished nature of the country. While the damage from crumbling and poorly built shacks and the lapse in electrical infrastructure was existent, the housing and power systems were so
poorly designed before the earthquake; it was obvious they would take a longer-term approach to mitigation. However, immediately after the earthquake, approximately 800 injury victims were received at the Hospital de L’Universite d’Etat d’Haiti. Immediately, the situation was that of battlefield hospice. Priority number one was getting a clear path to the Hospital, so that qualified physicians and volunteers could assemble and attend to the influx of patients. The United States acted swiftly in providing security forces to critical medical facilities, as well as the deployment of the USS Comfort Naval Hospital with its 500 beds. Immediately, the most severe patients were moved to the Comfort using Field Litter Ambulances (FLA) of 4 patients to a vehicle, which were driven to a landing zone, and then flown by helicopter to the ship. If it were not for the ability to transfer patients to the Comfort, many more lives would have been lost. (Auerbach, 2010). One problem that persisted, however, was clarity of messages and communication. In one example, it took a day to clarify the types of cases that should be relegated to the Comfort for treatment; the answer finally came in a list of medically acceptable conditions that should be given priority for transfer to the floating hospice.

**Deepwater Horizon Oil Spill**

Considering the Deepwater Horizon incident of April 2010, the unique circumstances of an oil spill stem from the lack of historical data regarding spills due to their infrequency relative to natural disasters. However, the same emergency response framework for natural disasters applies to the management of man-made environmental disasters. Much in the same response to Hurricane Katrina, the United States Coast Guard has assumed pivotal command over the cleanup and environmental hazard operations in cooperation with the Environmental Protection Agency, and Department of
the Interior/Minerals Management Service as well as state agencies such as the Louisiana and Texas Departments of Fish and Wildlife. Because of the location of the epicenter of the spill in coastal waters, the infrastructure for the majority of the coastal population is not severely affected. However, the need for accurate, relevant and available communications from British Petroleum (BP) and the United States Unified Command has constantly come under scrutiny. As soon as the spill occurred, the NIMS system notified first responders including fire chiefs and their staff along the coast, to the potential need for emergency response to the spill and its after-effects. When firefighters received no response from Unified Command except that any “action taken without consent would lead to criminal consequences”, the local responders began their own effort to deploy boom and use local knowledge to mitigate the damage to coastal wetlands. Jamie Hinton, Chief of Magnolia springs, Alabama Volunteer Fire Department, stated that “when the spill happened, BP unified command could have taped local knowledge to develop tailored approaches based on an area’s topography.” (Roberts, 2010). The criterion for surveillance was neglected, and the acquisition of relevant, available information was overlooked. This understates the inherent need for perpetual diligence in applying new strategies and testing better approaches to emergency response.

**Conclusion**

What becomes apparent in evaluating the developments of supply chain and logistics response to major catastrophe, if the constantly evolving nature of the field of emergency response. There is no perfect scenario that can be planned for, and the best chance for adequate response is to mitigate as much of the uncertainty and risk as is
possible through preparedness, simulation and contingency planning. We have seen that each level in the hierarchy of inter-organizational cooperation faces unique beauracracy, economic and systemic deficits, that only the further intense collaboration of resources, knowledge and experience can help to minimize. Federal beaurocracy benefits from scale of distribution, transport and human resources levels yet these strengths often result in slower decision making, whereas farther down the supply/communications/command chain, response is much more agile, yet lacks the materiel support to be truly effective. By both relying on the tested private sector examples of Business Contingency Plans—which are forged from the bottom line responsibility to stakeholders and occur in the business environment where success is measured in efficiencies—as well as through priority given the areas of successful information exchange and deeper transport channel analysis, a push-pull hybrid strategy of pre-positioning and postponement creates an environment that encourages collaboration along the emergency response supply chain.
Reference


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