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Strategies for Logistics in Case of a Natural Disaster

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Preface & Acknowledgements

During his internship with the Graduate School of Business & Public Policy in June 2010, U.S. Air Force Academy Cadet Chase Lane surveyed the activities of the Naval Postgraduate School's Acquisition Research Program in its first seven years. The sheer volume of research products—almost 600 published papers (e.g., technical reports, journal articles, theses)—indicates the extent to which the depth and breadth of acquisition research has increased during these years. Over 300 authors contributed to these works, which means that the pool of those who have had significant intellectual engagement with acquisition issues has increased substantially. The broad range of research topics includes acquisition reform, defense industry, fielding, contracting, interoperability, organizational behavior, risk management, cost estimating, and many others. Approaches range from conceptual and exploratory studies to develop propositions about various aspects of acquisition, to applied and statistical analyses to test specific hypotheses. Methodologies include case studies, modeling, surveys, and experiments. On the whole, such findings make us both grateful for the ARP's progress to date, and hopeful that this progress in research will lead to substantive improvements in the DoD's acquisition outcomes.

As pragmatists, we of course recognize that such change can only occur to the extent that the potential knowledge wrapped up in these products is put to use and tested to determine its value. We take seriously the pernicious effects of the so-called "theory–practice" gap, which would separate the acquisition scholar from the acquisition practitioner, and relegate the scholar's work to mere academic "shelfware." Some design features of our program that we believe help avoid these effects include the following: connecting researchers with practitioners on specific projects; requiring researchers to brief sponsors on project findings as a condition of funding award; "pushing" potentially high-impact research reports (e.g., via overnight shipping) to selected practitioners and policy-makers; and most notably, sponsoring this symposium, which we craft intentionally as an opportunity for fruitful, lasting connections between scholars and practitioners.

A former Defense Acquisition Executive, responding to a comment that academic research was not generally useful in acquisition practice, opined, "That's not their [the academics'] problem—it's ours [the practitioners']. They can only perform research; it's up to us to use it." While we certainly agree with this sentiment, we also recognize that any research, however theoretical, must point to some termination in action; academics have a responsibility to make their work intelligible to practitioners. Thus we continue to seek projects that both comport with solid standards of scholarship, and address relevant acquisition issues. These years of experience have shown us the difficulty in attempting to balance these two objectives, but we are convinced that the attempt is absolutely essential if any real improvement is to be realized.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the Acquisition Research Program:

- Office of the Under Secretary of Defense (Acquisition, Technology & Logistics)
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- Office of the Assistant Secretary of the Air Force (Acquisition)
- Office of the Assistant Secretary of the Army (Acquisition, Logistics, & Technology)
- Deputy Assistant Secretary of the Navy (Acquisition & Logistics Management)
- Director, Strategic Systems Programs Office
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- Defense Business Systems Acquisition Executive, Business Transformation Agency
- Office of Procurement and Assistance Management Headquarters, Department of Energy

We also thank the Naval Postgraduate School Foundation and acknowledge its generous contributions in support of this Symposium.

James B. Greene, Jr.
Rear Admiral, U.S. Navy (Ret.)

Keith F. Snider, PhD
Associate Professor

Panel 22 – Acquisition and Logistics in Support of Disaster Relief and Homeland Security

Thursday, May 12, 2011	
1:45 p.m. – 3:15 p.m.	**Chair: Rear Admiral Kathleen Dussault,** SC, USN, Director, Supply, Ordnance, & Logistics Operations Division, Office of the Chief of Naval Operations ***Strategies for Logistics in Case of a Natural Disaster*** Keenan Yoho and Aruna Apte, NPS ***An Analysis of U.S. Navy Humanitarian Assistance and Disaster Relief Operations (MBA Student Report)*** LT Cullen Greenfield and LT Cameron Ingram, USN ***Financing Naval Support for Humanitarian Assistance & Disaster Response: A Cost Analysis and Planning Model (MBA Student Report)*** LCDR Stephen Ures, USN ***When Disaster Strikes: Is Logistics and Contracting Support Ready?*** Aruna Apte and E. Cory Yoder, NPS

Rear Admiral Kathleen Dussault—Director, Supply, Ordnance and Logistics Operations Division (OPNAV N41). Rear Admiral Kathleen Dussault assumed duties as the director of Supply, Ordnance and Logistics Operations in the Office of Chief of Naval Operations (OPNAV N41) in March 2009. Dussault comes to OPNAV from her most recent assignment as commander of the Joint Contracting Command Iraq/Afghanistan, headquartered in Baghdad, Iraq, with 18 regional offices throughout both theaters.

Dussault graduated from the University of Virginia in 1977 with a Bachelor of Arts in American Government, received her commission through Officer Candidate School in Newport, RI, in November 1979, and graduated from Navy Supply Corps School in May 1980. Dussault has served in USS *Point Loma* (AGDS-2) in the Pacific Area Launch Support Ship for the Trident missile program as supply officer, USS *Concord* (AFS-5) as the assistant supply officer during Operations Desert Shield and Desert Storm, and as supply officer aboard USS *Seattle* (AOE-3), where she served as Afloat Logistics coordinator while deployed to the 5th Fleet operating area.

Dussault's shore tours include assistant supply officer and disbursing officer to the Navy Communications Station, Nea Makri, Greece; Defense Contract Administration Services Region (DCASR), Los Angeles; a negotiator and contracting officer at Naval Supply Center, Oakland, CA; procuring contracting officer for the Sidewinder and deputy for Missile Systems Acquisition at Naval Air Systems Command (NAVAIR); business and financial manager for programs managed by the Space and Naval Warfare Command; and executive assistant to the Deputy Assistant Secretary of the Navy for Acquisition Management within the office of the Assistant Secretary of the Navy for Research Development and Acquisition. In May 2001, Dussault assumed command of Defense Distribution Depot San Diego, and in April 2003 she assumed command of the Office of Special Projects, Arlington, VA. She then served as deputy director of Acquisition Management at Defense Logistics Agency, Fort Belvoir, VA. Prior to her combat assignment, she was assigned as deputy assistant secretary of the Navy for Acquisition and Logistics Management in Washington.

Dussault has earned a master's degree (with honors) in procurement management from Saint Mary's College in Moraga, CA, and a master's degree in national resource strategy from the Industrial College of the Armed Forces. She has achieved the highest levels of accreditation in Acquisition, Financial and Supply Chain Management and Joint Professional Military Education. Dussault is certified in production and inventory management through APICS, the educational society for resource management. She has completed the Executive Education Program at Columbia Business School.

Her decorations include the Defense Superior Service Medal, Legion of Merit, Bronze Star, Navy Meritorious Service Medal with two gold stars, Joint Service Commendation Medal, Navy Commendation Medal, Navy Achievement Medal with gold star and various unit citations, campaign medals and service medals.

Strategies for Logistics in Case of a Natural Disaster

Keenan Yoho—Assistant Professor, Graduate School of Business & Public Policy, NPS. Professor Yoho's primary research activities are in the area of the analysis of alternatives for capital purchases under conditions of resource scarcity, supply chain management, risk analysis, humanitarian assistance and disaster response, and resource management in environments that exhibit high degrees of uncertainty.

Prior to joining the Naval Postgraduate School, Professor Yoho was an operations researcher and principal investigator with The RAND Corporation, a federally funded research and development center (FFRDC) where he led studies for the Army, Air Force, and TRANSCOM to improve the effectiveness of logistics, acquisition, and sustainment operations and to develop policy guidance for supply chain operations.

Professor Yoho has several years of experience teaching and developing master's students and executives in the U.S. and Europe in principles of supply chain management and manufacturing operations. He has served as an Intelligence Analyst for the U.S. Customs Service in the area of international money laundering and has worked large litigation cases representing Lloyd's of London in insurance defense. He was the National Research Coordinator for Manufacturing Skills Standards as part of an initiative funded by the United States Congress to develop national skill standards for the U.S. industrial manufacturing economic sector. He has advised U.S. and European firms for several years in the petrochemical, semiconductor, paper and pulp products, and steel industries focusing on enabling corporate strategy by using the supply chain as a competitive weapon.

Professor Yoho holds a PhD in Operations Management, an MBA in Operations and Information Management, and an MS in Industrial Relations from the University of Wisconsin–Madison. He also holds a BA in Religion with a concentration in Chinese and Japanese Buddhism from Temple University. [kdyoho@nps.edu]

Aruna Apte—Assistant Professor, Department of Operations and Logistics Management, NPS. Professor Apte has successfully completed various research projects, involving application of mathematical models and optimization techniques that have led to over 20 research articles and one patent. Her research interests are in developing mathematical models for complex, real-world operational problems using optimization tools. She values that her research be applicable. Currently her research is focused in humanitarian and military logistics. She has several publications in journals, such as *Interfaces, Naval Research Logistics, Production and Operations Management*. She has recently published a monograph on Humanitarian Logistics (http://dx.doi.org/10.1561/0200000014).

Professor Apte received her PhD in Operations Research from Southern Methodist University in Dallas. She also has an MA in Mathematics from Temple University, Philadelphia. Before NPS she worked as a consultant at MCI and taught at the Cox School of Business, SMU, where she won the best teacher award. She has over 20 years of experience teaching operations management, operations research, and mathematics courses at the undergraduate and graduate levels. At NPS, she teaches mathematical modeling, for which she won the best teacher award, and she has advised over 50 students for over 24 MBA/Masters reports, out of which 10 students have worked and seven more are working in Humanitarian Logistics. She has also advised emergency planners in preparing for disaster response. She is the founding president for a new college (focus group) in Humanitarian Operations and Crisis Management under the flagship academic professional society in her intellectual area of study, Production and Operations Management Society. [auapte@nps.edu]

Abstract

The need to effectively and efficiently provide emergency supplies and services is increasing all over the world. We investigate policy options: prepositioning supplemental resources, preemptive as well as phased deployment of assets, and surge of supplies and services. We hypothesize that there exists a correlation

between these policies and our disaster classification based on localization (dispersed or local) of the disaster and its speed of onset (slow or sudden). We believe that the creation of a matrix and designation of policies based on disaster type will facilitate the policy makers' decision process. Exploring the efficacy of each policy option with respect to several crisis scenarios to assist policy makers to better prepare their disaster response is critical in Humanitarian Assistance and Disaster Response.

Introduction

In 2009 there were "335 natural disasters reported worldwide that killed 10,655 persons, affected more than 119 million others, and caused over $41.3 billion in economic damages" (Vos, Rodriguez, Below, & Guha-Sapir, 2009). The number of natural disasters reported between 1900 and 2007 has increased significantly and with it, the number of requests for aid and humanitarian assistance (see Figure 1). While the trend in the number of disasters reported shows an increase, it is not clear that there has been a commensurate response in terms of preparedness. The United States Agency for International Development (USAID) reports that of all funds used to support disaster operations, 90% are spent for response, whereas 10% are spent on preparedness activities and investments and risk reduction (A. Giegerich, personal communication, 2010). The United Nations estimates that every dollar spent to prepare for a disaster saves seven dollars in disaster response (United Nations Human Development Program, 2007).

Although the objective of all the organizations and agencies involved in humanitarian assistance is to reduce human suffering and casualties, the duration and severity of the human toll during a natural disaster is largely dependent upon the speed and scope of the response, which is often a function of the level of preparedness that has been established prior to the disaster event. While there are no internationally agreed upon metrics by which to judge or measure the effectiveness of a response to a disaster, scholars working in the humanitarian and disaster response research area have found that improvement is desirable (Apte, 2009; Van Wassenhove, 2006). An effective and efficient humanitarian response depends "on the ability of logisticians to procure, transport and receive supplies at the site of a humanitarian relief effort" (Thomas, 2003). In this research we focus on the response to a disaster area in the form of distributing supplies, and strategies that will enhance the effectiveness of such a response.

As part of our investigation, we will explore four policy options: (1) prepositioning supplemental resources in or near the incident location, (2) proactive deployment of assets in advance of a request, (3) phased deployment of assets and supplies, analogous to the "just in time" inventory control philosophy practiced by many commercial manufacturers, and (4) "surge" transportation of manpower and equipment from locations outside the disaster area.

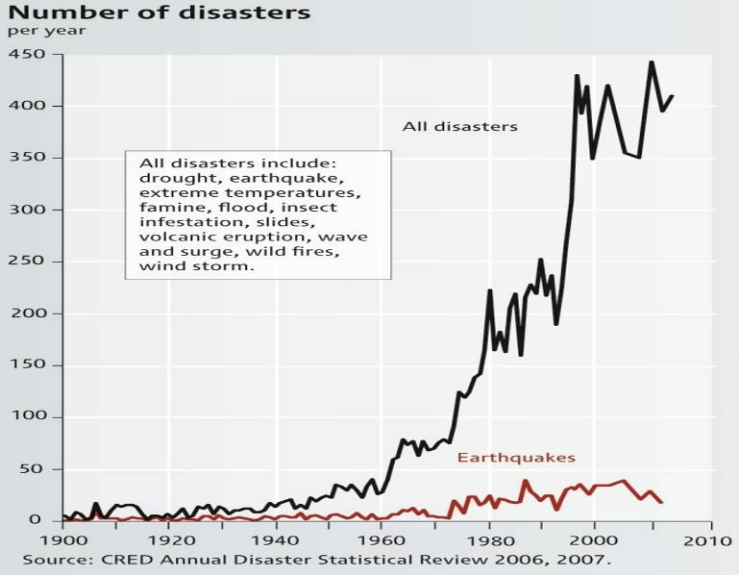

Figure 1. Number of Disasters Reported from 1900–2007
(UNEP/GRID, 2009)

Literature Review

One of the major issues in a response supply chain in case of a natural disaster is to coordinate the operations and relief inventories over a large number of stages, locations, and organizations. This has to be done while providing the emergency supplies and services to the affected population under extreme conditions. Decisions regarding the types of provisions that should be prepositioned, as well as their location, should be made well before a disaster strikes in order to provide quick response. To some extent, without such a high level of uncertainty and an adverse environment, it is similar to the core question in supply chain management of coordinating activities and inventories over a spectrum of stages of the supply chain and facility locations of the inventory (Schoenmeyr & Graves, 2009).

In the private sector, it has been found that if each individual stage in a serial-system of the supply chain operates with a designated base stock policy with service guarantees, then the optimal safety stock strategy is to maintain inventory at certain key locations which results in separating the stages of the supply chain. This allows each stage to operate independently by minimizing the need for communication and coordination amongst players (Simpson, 1958; Graves & Willems, 2003). Models available in supply chain management literature are predominantly with unlimited capacity for storage. In cases where there is unlimited capacity, the amount of safety stock needed is less than the level needed with capacity constraint (Schoenmeyr & Graves, 2009).

Literature discussing strategic inventory placement under evolving or pre-determined forecasts (Graves & Schoenmeyr, 2008; Simpson, 1958) suggests policies for the optimal placement of safety stocks in a supply chain. Graves and Willems (2002) study this problem accounting for uncertain as well as non-stationary demand. This concept can be translated to the response supply chain due to the type of demand in a disaster response (Apte, 2009; Ergun, Heier, & Swann, 2008). There has been much more published work available with stationary demand as opposed to non-stationary demand. Most of the non-stationary demand has been modeled as a Markov–modulated Poisson demand process (Chen &

Song, 2001; Graves & Abhyankar, 2001). One of the primary conclusions for safety stock with non-stationary demand is that an inter-phase optimal policy need not be the same as the intra-phase policy (Graves & Willems, 2002).

In addition to the prepositioning of relief inventories, a disaster response may require the formulation of policies that require the expansion of warehouses, medical facilities, and temporary shelters, while infrastructure preparation may include the provision of airstrips and ramp space at existing airfields (Salmeron & Apte, 2010). Regnier (2008) has explored the relationship between forecasting the time and location of a hurricane landfall and the amount of time necessary to evacuate a high-risk area; as the hurricane gets closer to land, the quality of the forecast increases; however, the time necessary to evacuate decreases. Though evacuation is not the focus of this research, the timing of the evacuation is an important factor when formulating logistics strategies in case of a disaster.

Koavacs and Spens (2007) weigh the difference between traditional commercial logistics and humanitarian logistics. With humanitarian logistics, it is imperative to go beyond the profitability of commercial logistics. Within the domain of humanitarian logistics, suppliers have different motivations for participating, and customers are not generating voluntary demand and will hopefully not create a "repeat purchase." Thus, supply networks must take into account the lack of true demand; demand will be dictated by the relief agencies which are the primary actors within this framework. Therefore, it is the responsibility of the agency to "push" the supplies to the disaster location in the immediate response phase, which is different from the commercial philosophy of pull-based demand. Humanitarian logistics focuses on getting the greatest volume of supplies to the points where they are needed, and there may be lessons learned in the commercial sector that could be used to improve the planning and execution of strategies that could be implemented during a disaster response.

Disaster Life Cycles

The life cycle of a disaster from the perspective of Humanitarian Assistance and Disaster Response (HADR) is divided into three stages (see Figure 2): being prepared in the pre-disaster stage, response as the disaster strikes, and recovery in post-disaster (Van Wassenhove, 2006; Apte, 2009). In order to mitigate the effects of a disaster, one could draw on policies proven to be effective in the private sector (Van Wassenhove, 2006), as well as those in current use by the U.S. military, since many of these policies have been tested and have matured over the years.

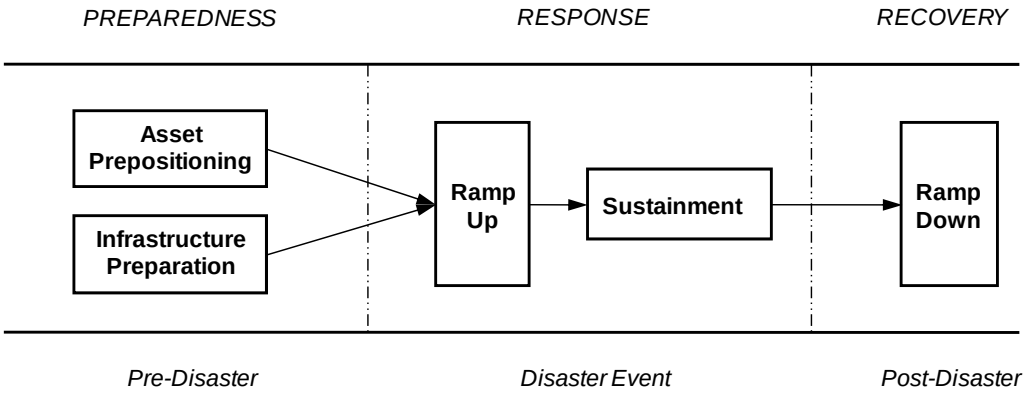

Figure 2. Life Cycle of Disasters
(Apte, 2009)

Disaster preparedness is the first step in mitigating the adverse impacts of any unforeseen catastrophic event. Preparedness on an individual level is defined by the creation of an escape and survival plan, as well as the procurement and storage of supplies that will enable an individual to act on the plan. Preparedness on an organizational or institutional level translates to the planning and pre-establishment of adequate capacity and resources that enable efficient relief operations. Prepositioning of war reserve and contingency stocks, such as that practiced by each of the U.S. Armed Services, has proven an effective means of increasing the speed of response to a conflict (Abell et al., 2000; Button, Gordon, Hoffman, Riposo, & Wilson, 2010; Hura & Robinson, 1991; McGarvey et al., 2010). The private commercial sector, too, has been involved in prepositioning strategic safety stocks in supply chains with evolving forecasts (Graves &Schoenmeyr, 2008), capacity constraints (Schoenmeyr & Graves, 2009), and non-stationary demands (Graves & Willems, 2002, 2008). In addition to the prepositioning of supplies, the U.S. Armed Services have excess capacity in combat, combat support, and combat service support in the form of reserves and National Guard, as well as specialized capabilities needed for crossing rivers, opening ports, and disposing of hazardous and explosive materials.

Disaster response is a function of the preparation that took place prior to the disaster event, as well as the coordination of available supplies and distribution capacity. The first part of the response consists of gaining situational awareness of events and conditions on the ground in the disaster area through the collection of available information, and then using this information and awareness to generate an operational picture that will inform the nature, scale, and timing of the response. The response itself is largely comprised of the tactical activities that must take place to move needed supplies to those parts of the disaster area that are in the most critical demand, given the available resources at hand.

Disaster recovery consists of stabilizing the disaster area and improving the living and economic conditions of those affected by the catastrophic event. The recovery phase will mean different things to different organizations. For the military, the recovery phase will likely signal the beginning of drawn-down or redeployment operations, whereby military personnel and equipment will be withdrawn and responsibility turned over to civil authorities. For non-governmental aid organizations, the recovery phase may consist of establishing semi-permanent camps, aid stations, or warehouses to shelter displaced persons, deliver critical services that cannot be provided by other civil authorities, and coordinate the storage and distribution of supplies that are otherwise unavailable or in short supply to the local population.

Studying the life cycle of recent disasters offers insight into both short-term and long-term consequences. They also provide us with numerous lessons to form effective strategies for mitigating future disasters. However, in order to formulate such strategies we need to understand disasters in terms of their speed and scope, especially since we believe they directly affect operational difficulty in preparedness, response, and recovery.

Disaster Classification

Disasters are often classified based on the speed of onset and the source or cause of the disaster (Ergun et al., 2008; Van Wassenhove, 2006). However, in our research, we focus on four disaster scenarios that are combinations of the geographic dispersion of the disaster (dispersed or localized) and its speed of onset (slow or sudden) as discussed by Apte (2009) and described in Figure 3. The disaster classification suggests that the level of difficulty in the logistics execution is less onerous in the case of localized, slow-onset

disasters (depicted in quadrant III of Figure 3), because there may be adequate lead time and local resources to prepare for the response.

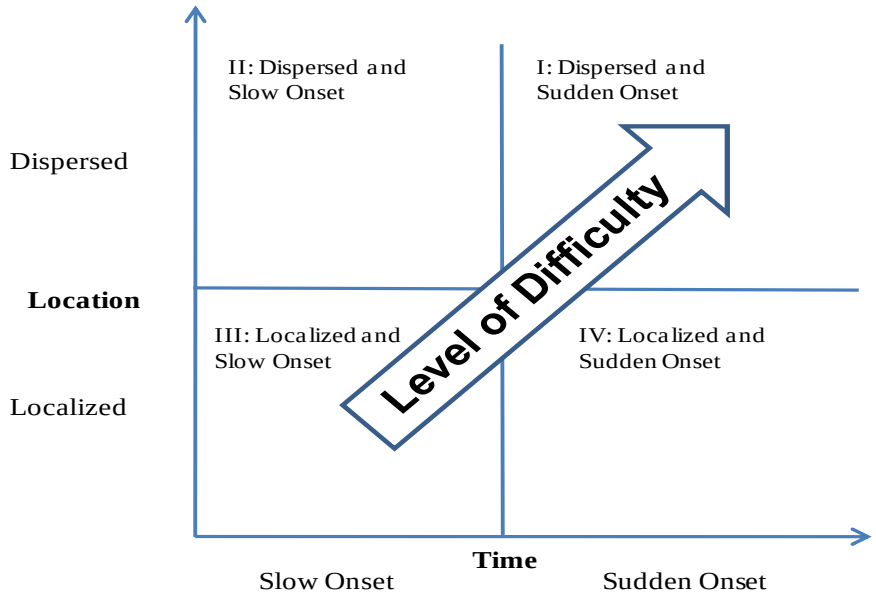

Figure 3. Classification of Disasters
(Apte, 2009)

Dispersed and sudden-onset disasters (depicted in quadrant I of Figure 3) tend to be the most catastrophic in humanitarian terms, because in this case, both a lack of warning and a large geographic region are affected. The recent earthquake and tsunami that occurred in Japan on March 11, 2011, was both rapid in its onset and dispersed in terms of its destruction; the tsunami alone covered a 420 square mile area of coastline, with most of the destruction taking place within an hour of the earthquake (Hirschberg & Richardson, 2011).

Quadrant II describes a context where the onset is slow but the affected area is geographically dispersed. When the disaster area consists of a large or scattered geographical area, it may take substantial planning, resource allocation, and coordination among the military, humanitarian organizations, local, federal, and perhaps even foreign government representatives. The 2009 avian flu epidemic is an example of a slow onset, geographically dispersed disaster involving multiple countries to respond to its effects. Although the numbers of people who have died from avian flu have been modest over the last five years, there remains a significant threat that the disease could mutate into an antibiotic-resistant strain that could eventually kill millions of people worldwide. The sudden-onset disaster, even if localized (depicted in quadrant IV of Figure 3), creates operational difficulties that are greater than circumstances where the onset is slow, but less than if the catastrophe were both rapid in its onset and geographically dispersed. Sudden-onset disasters deny authorities and the public time to prepare for the consequences of the disaster event and therefore tend to exact a much higher human cost.

The disasters with slow-onset provide time for humanitarian logisticians to plan and prepare for relief operations. A disaster that strikes suddenly can pose difficult problems for response since no organization—military or humanitarian—can fully prepare for every need that will emerge during such an event. However, prepositioning strategies such as asset

placement, resource allocation, management of disaster relief inventory, and location of such warehouses may help. It is clear that whether the disaster is localized or dispersed over a large geographical area, will dictate the level of difficulty involved in disaster response.

In all these situations, where disasters may be slow-onset or sudden-onset, localized or dispersed, pre-positioning seems to be the policy that will always be more effective and efficient in HADR. The utilization of pre-positioning in private, as well as public sector, suggests that we formulate logistics strategy based on this concept.

Discussion

The unpredictability of the timing of a disaster, as well as the scope of its human and material destruction, raises several serious questions for emergency planners and first responders. For example, how can a state of supply preparedness be established and maintained? How should adequate prepositioned disaster relief inventory be established and sustained over time to include the rotation of perishable stocks? How can information regarding the location, quantity, and condition of prepositioned inventory be shared and what effect would this information sharing have on the total investment of prepositioned stocks? Is prepositioning the best strategy for all types of disasters? How reliable are the potential supply lines if it is determined that supplies should be virtually stockpiled (that is, a detailed list or database of supplies by type and quantity is created and maintained, as well as reliable sources that can provide the supplies quickly)? Should supplies be sourced locally or from outside the disaster zone? Answers to these questions depend on the expected onset speed of the disaster, the volume and weight of supplies to be moved, the expected magnitude of humanitarian relief required, and the expected likelihood of a disaster in the area.

The success of the military in using prepositioned stocks has developed interest in the prospect of using such a strategy to support operations other than war (Brown, Schank, Dahlman, & Lewis, 1997; Salmeron & Apte, 2010). Prepositioning supplemental resources in or near the incident location most resembles the military practice of storing defense inventory ashore to be used in the event of a conflict; the Army-prepositioned stocks in Southwest Asia, as well as those in Korea, are good examples. An alternative to prepositioning would be the early deployment of assets in advance of a local government request. For example, as federal government officials see a hurricane approaching the Gulf of Mexico, they could mobilize food, water, and temporary shelters and stage them close to, but not in, the expected disaster zone so that when these supplies are needed, the lead time necessary to deliver them is reduced. Phased deployment of assets refers to timing the delivery of inventory to a disaster area as it is needed and in the quantity in which it is needed. This disaster response is analogous to “just in time” inventory control practiced by commercial manufacturers, and has the advantage of not committing excess inventory to a specific region before knowing precise types and quantities of supplies needed. Phased deployment also prevents the disaster zone from being inundated or saturated with inbound materiel that might otherwise reduce the overall effectiveness of the disaster response due to inadequate infrastructure or limitations in personnel, material handling equipment, storage space, or some combination of all three.

A surge in transportation of manpower and equipment from locations outside the disaster area is a final alternative that, rather than relying on prepositioned physical inventory, plans for excess capacity to deliver personnel and materiel in case of an emergency; in this instance, the “prepositioning” is with respect to capacity rather than

inventory. The organizations involved in humanitarian assistance and disaster response (such as those relevant agencies within the Department of Defense, civil and military agencies, and participating Non-Government Organizations) face issues of information availability, interoperability in communications and equipment, coordination of specialized skill sets, and determination of which organization will lead specific phases of the operation which affect the ability to collaborate and preposition supplies. A preliminary look at the above-mentioned four strategies related to the life cycle of a disaster suggests the assignment of strategies as shown in Figure 4.

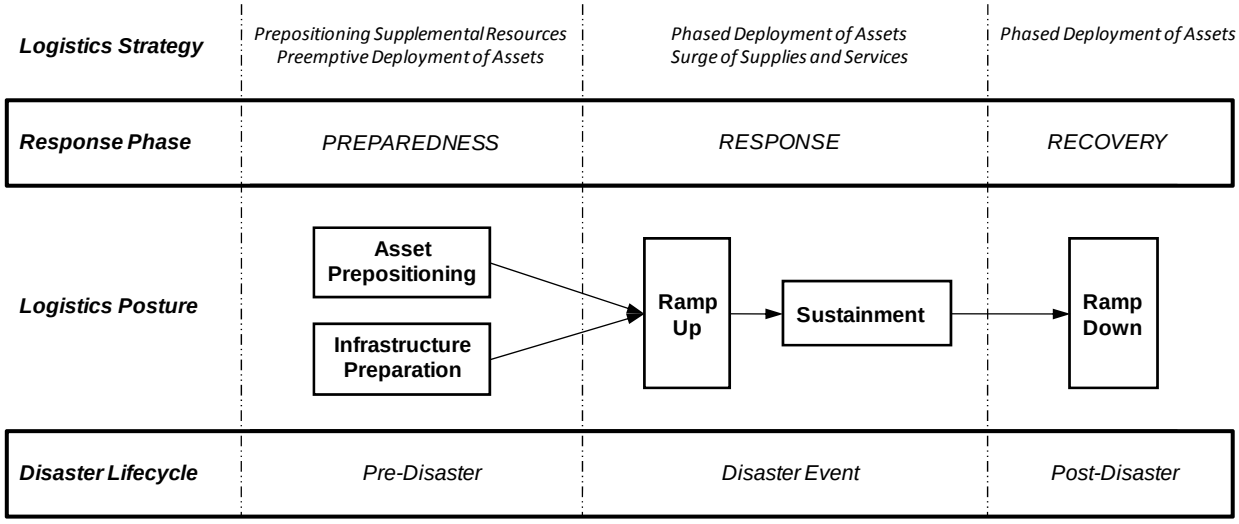

Figure 4. Policies Related to Life Cycle of a Disaster

Note. Figure 4 is adapted from Apte (2009).

Conclusion

The localized, slow-onset and natural disasters are at one end of the spectrum with respect to the level of difficulty for humanitarian logistics, whereas dispersed, sudden-onset disasters are at the other. Classification of disasters and the life cycle of a disaster are our basis for formulating which of the four policies should be used when. The conceptual models we plan to develop in this work will serve as the theoretical base for future empirical work investigating appropriate policy options for different classifications of disasters. We believe the proposed research will create a comprehensive understanding of strategies in logistics for HADR; recommend strategies in logistics that are appropriate to different types of disasters; and recommend strategies in logistics that are appropriate to specific regions of the world.

Way Forward

Utilizing both qualitative and quantitative methods to include process analysis, cost analysis, and case studies, we will introduce four policy options to respond to a disaster or humanitarian relief effort, and explore the efficacy of each one against the backdrop of four different disaster scenarios. Policy options will be developed that correspond to classes of disaster and operational difficulty to improve the decision process of policy makers in terms of resource acquisition and deployment. We plan to pursue the following methodology to achieve this goal.

We will expand upon our current review of the academic literature to identify work that has addressed inventory prepositioning in the public (to include defense) and private

sector. We will identify examples of four candidate logistics strategies—prepositioning supplemental resources in or near the incident location; deploying federal assets in advance of a state or local government request; phased deployment of assets, analogous to the "just in time" inventory control philosophy practiced by many manufacturers; and "surge" transportation of manpower and equipment from locations outside the disaster area—in the public and private sector. We will evaluate logistics strategies within the context of the four types of disaster scenarios and develop policy recommendations.

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