EMERGENCY PETROLEUM SUPPLY CHAINS

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE
Homeland Security Studies

by

JASON H. EATON, MAJ, US ARMY
B.S., Norwich University, Northfield, Vermont, 2007
M.S., University of New Haven, West Haven, Connecticut, 2017

Fort Leavenworth, Kansas
2018

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
15-06-2018	Master's Thesis	AUG 2017 – JUN 2018

4. TITLE AND SUBTITLE

Emergency Petroleum Supply Chains

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

MAJ Jason H. Eaton

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Command and General Staff College
ATTN: ATZL-SWD-GD
Fort Leavenworth, KS 66027-2301

8. PERFORMING ORG REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution is Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The complexity of emergency supply chains represents challenges towards their efficiency and effectiveness during disaster response. Petroleum is a key commodity distributed by emergency supply chains, to offset petroleum shortages caused by a catastrophic incident. Safeguarding petroleum supply distribution is an economic interest of the *National Security Strategy* and is addressed by the *National Response Framework* through the core capability of "Logistics and Supply Chain Management." Leveraging this core capability is coordinated through the Emergency Support Function 12: Energy to facilitate the restoration of petroleum supply chains and return communities to a sense of normalcy after a disaster. During Hurricane Sandy, petroleum supply was severely disrupted requiring the necessity of emergency petroleum supply chains. To assess emergency petroleum supply chains during Hurricane Sandy, a Center of Gravity (COG) analysis is applied to ascertain the critical capabilities, critical requirements, and critical vulnerabilities. As an alternative approach towards reducing the complexity of emergency supply chains, the goal of the application is to demonstrate how the COG concept can assist in future disaster-based planning and response.

15. SUBJECT TERMS
Emergency Supply Chains; Center of Gravity; Disaster Response; Petroleum Supply Disruption; Hurricane Sandy.

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. PHONE NUMBER** *(include area code)*
(U)	(U)	(U)	(U)	85	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

MASTER OF MILITARY ART AND SCIENCE

THESIS APPROVAL PAGE

Name of Candidate: MAJ Jason H. Eaton

Thesis Title: Emergency Petroleum Supply Chains

Approved by:

_____, Thesis Committee Chair
O. Shawn Cupp, Ph.D.

_____, Member
Russell G. Conrad, M.S.

_____, Member
Gregory P. Bedrosian, M.S.

Accepted this 15th day of June 2018 by:

_____, Director, Graduate Degree Programs
Robert F. Baumann, Ph.D.

The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

EMERGENCY PETROLEUM SUPPLY CHAINS, by MAJ Jason H. Eaton, 85 Pages.

The complexity of emergency supply chains represents challenges towards their efficiency and effectiveness during disaster response. Petroleum is a key commodity distributed by emergency supply chains, to offset petroleum shortages caused by a catastrophic incident. Safeguarding petroleum supply distribution is an economic interest of the *National Security Strategy* and is addressed by the *National Response Framework* through the core capability of "Logistics and Supply Chain Management." Leveraging this core capability is coordinated through the *Emergency Support Function 12: Energy* to facilitate the restoration of petroleum supply chains and return communities to a sense of normalcy after a disaster. During Hurricane Sandy, petroleum supply was severely disrupted requiring the necessity of emergency petroleum supply chains. To assess emergency petroleum supply chains during Hurricane Sandy, a Center of Gravity (COG) analysis is applied to ascertain the critical capabilities, critical requirements, and critical vulnerabilities. As an alternative approach towards reducing the complexity of emergency supply chains, the goal of the application is to demonstrate how the COG concept can assist in future disaster-based planning and response.

ACKNOWLEDGMENTS

I would like to thank my wife Stephanie for her love and support during the writing of this thesis. Her words of encouragement were instrumental throughout the pursuit of research.

Secondly, I would like to thank Dr. Shawn Cupp, Mr. Russell Conrad, and Mr. Gregory Bedrosian for their time and for serving on the thesis committee. Their continued guidance and constructive aid are greatly appreciated.

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ACRONYMS

COG	Center of Gravity
DOE	Department of Energy
DOD	Department of Defense
DHS	Department of Homeland Security
DLA	Defense Logistics Agency
DSCA	Defense Support of Civil Authorities
ESF	Emergency Support Function
FEMA	Federal Emergency Management Agency
FM	Field Manual
HS	Homeland Security
JCE	Joint Coordination Element
JFO	Joint Field Office
JP	Joint Publication
NIMS	National Incident Management System
NRF	National Response Framework
NSS	National Security Strategy
USNORTHCOM	US Northern Command

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CHAPTER 1

INTRODUCTION

To achieve the objective of emergency petroleum distribution during catastrophic incidents, the *National Response Framework* (NRF) integrates efforts amongst government agencies and the private sector. As an overarching national document, the NRF is an enduring construct for how local, state, federal, and tribal governments will respond to disasters through unified action (DHS 2016, 1). The core capability of "Logistics and Supply Chain Management" is leveraged by the NRF to facilitate petroleum distribution by way of emergency supply chains (DHS 2016, 25). The importance of emergency petroleum distribution is to mitigate the effects of a fuel shortage caused by a catastrophic incident. Effects of a fuel shortage can weaken the Nation's economy and destabilize local communities, which can affect life, property, and the environment (DOE 2013, 40). Due to the significance of these effects, the 2017 *National Security Strategy* (NSS) stresses the importance of reducing petroleum supply disruption from physical threats such as hurricanes (U.S. President 2017, 23). At a strategic level, the NRF provides ways to conduct emergency petroleum distribution through the means of "Logistics and Supply Chain Management" to achieve the ends of reducing petroleum supply disruptions.

When responding to a catastrophic incident, emergency supply chains are vital entities of the "Logistics and Supply Chain Management" core capability. To specifically address the demands of a fuel shortage, national response actors implement emergency petroleum supply chains within the continuum of emergency supply chains. However, emergency supply chains are a relativity new concept, only coming to institutional

prominence after the 2004 Asian Tsunami (Thomas and Kopczak 2005, 1). Since 2004, academic and professional institutions have been assessing the "special characteristics" of emergency supply chains and their variations from commercial supply chains (Decker 2014, 25). As dynamic entities which need to be effective and efficient in providing timely disaster response, emergency supply chains, and more specifically, emergency petroleum supply chains, leverage both government and private sector resources (Ji and Zhu 2012, 314). Together as unified action partners, government organizations and the private sector contribute resources within the guidelines of the NRF towards emergency petroleum supply chains to mitigate the effects of a fuel shortage during a catastrophic incident.

Fuel Shortage during Hurricane Sandy

Hurricane Sandy is an example of a catastrophic incident creating a fuel shortage in which national response actors leveraged emergency petroleum supply chains. Before Hurricane Sandy made landfall on October 29, 2012, the Northeast region of the United States required 2.2 million barrels of gasoline and other petroleum products a day (NACS 2013, 64). To support the petroleum requirement of 2.2 million barrels a day, petroleum products are delivered by pipeline, local refineries, and imports, with a majority of the petroleum supply imitating from local refineries (NACS 2013, 64). Of those refineries, Hurricane Sandy disrupted six refineries once it made landfall. These six refineries had a refining capacity of 1.29 million barrels a day, correlating to 7% of the nation's refining capacity (NACS 2013, 65). Hurricane Sandy's disruption caused a 28% reduction in refining capacity or a loss of 290,000 barrels per day (DOE 2013, 15). Additionally, Hurricane Sandy restricted import operations at nine different ports, resulting in a loss of

668,000 barrels per day, and closed three petroleum pipelines till the 3rd of November (DOE 2013, 17, 18). Due to these petroleum supply disruptions coupled with extensive power outages, only one-third of retail refueling stations remained open within the affected region, creating a fuel shortage (DOE 2013, 24). However, before the fuel shortage became a reality, the Federal government, through the guidelines of the NRF began to anticipate the need for emergency petroleum supply chains.

As Hurricane Sandy moved up the Atlantic coastline of the United States, it was categorized as a level one hurricane. On October 26th, the Federal Emergency Management Agency (FEMA) activated *Emergency Support Function 12: Energy* (ESF 12: Energy) and coordinated with state officials, contractors, and supporting Federal agencies, such as the Defense Logistics Agency-Energy (DLA-Energy). Additionally, the Department of Defense (DOD) combatant command responsible for the continental United States, the US Northern Command (USNORTHCOM), issued deployment orders for units to conduct Defense Support of Civil Authorities (DSCA) operations on October 27th. In conjunction with these actions, DLA-Energy started coordination with Foster Fuels, a private contractor, to stage 60 fuel trucks at Joint Base McGuire-Dix-Lakehurst in New Jersey. On the night of the 28th, the Department of Energy (DOE) issued its first situation report indicating port restrictions and refineries that were preparing for the hurricane. To facilitate the release of Federal resources, the President declared an Emergency Declaration for states within Hurricane Sandy's projected path. During the 29th of October, the DOE issued follow up situation reports indicating additional port restrictions and refinery closings along the US east coast. With a looming catastrophic

incident, the actions of the Federal government followed the guidelines of the NRF as Hurricane Sandy was approaching landfall.

After Hurricane Sandy made landfall on the night of October 29th, the Federal government began to take a more aggressive posture towards implementing emergency petroleum supply chains. On October 30th, the President declared a Major Disaster Declaration for the State of New York and its neighboring states. With this declaration, the Sectary of Defense authorized USNORTHCOM to begin DSCA operations in support of FEMA activities. Additionally, Foster Fuels was requested to surge fuel distribution capabilities at Joint Base McGuire-Dix-Lakehurst in New Jersey and amassed 300 fuel transportation assets. Also during this time, the Governor of New York submitted a Request for Assistance to the Secretary of Defense for a Dual-Status Commander to manage DSCA operations within the state. To support this request, USNORTHCOM established a Joint Coordinating Element at Joint Base McGuire-Dix-Lakehurst to coordinate Title 10 Forces (Active Duty) for US Army North as the Joint Force Land Component Command. Dual-Status Commanders were established to oversee both Title 10 and Title 32 (National Guard) forces conducting tactical DSCA operations in both New York and New Jersey. The DOE issued additional situation reports, indicating the status of refineries, ports, terminals, and pipelines affected by the storm. Due to the hurricane's effects, FEMA requested Foster Fuels to establish additional fuel sites in New Jersey on the first of November. With the situation deteriorating, the DOE authorized the first-ever transfer from the Northeast Home Heating Oil Reserve to offset petroleum shortages. Additionally, to mitigate fuel shortages, the Jones Act was waived allowing foreign-flagged fuel ships to transfer fuel from one US domestic port to another. On the

3rd and 9th respectively, the States of New Jersey and New York implemented fuel rationing. To bolster the existing emergency petroleum supply chains, Task Force Support was deployed from Fort Drum, New York on the 5th of November with 59 M978 Heavy Expanded Mobility Tactical Truck (HEMTT) fuel trucks to Joint Base McGuire-Dix-Lakehurst. From this support base, these military fuel trucks, with a fuel capacity of 2,500 gallons each, began petroleum distribution operations throughout New Jersey. By the 21st of November, Foster Fuels issued 1,098,400 gallons and 2.9 million gallons to New Jersey and New York fuel retail locations respectively. Towards the end of November, all refiners resumed normal operations, and emergency petroleum supply chains ceased. On the 3rd of December 2012, the DOE issued its last situation report indicating the end of the fuel shortage.

Purpose

The purpose of this study is to reduce the complexity of emergency supply chains, which affects their efficiency and effectiveness during disaster response. To investigate the complexity, a Center of Gravity (COG) construct is used to determine the critical factors of emergency supply chains. The goal of the investigation is to demonstrate how the COG construct can determine critical capabilities, critical requirements, and critical vulnerabilities as a way of reducing the complexity of emergency supply chains.

Research Questions

This study proposes three research questions to investigate the complexity of emergency petroleum supply chains. The first research question is, “What are the critical factors of emergency petroleum supply chains during the Hurricane Sandy?” Critical

factors are the critical capabilities, critical requirements, and critical vulnerabilities emanating from the Center of Gravity (COG) concept. Chapter Two will discuss the COG concept and its significance to this study. The second research question is, "How effective was the *National Response Framework* in planning for and managing emergency petroleum supply chains?" This question seeks to explore the effectiveness of the NRF in meeting the fuel shortage caused by Hurricane Sandy by leveraging emergency petroleum supply chains. The third research question is, "How does this study advance the understanding of emergency supply chains?" The goal of the third research question is to determine whether the COG concept is an appropriate planning element for emergency supply chains. Together, the three research questions direct the investigation of emergency petroleum supply chains.

Assumptions

Assumptions made by this study focus on the applicability and feasibility of emergency petroleum supply chains during Hurricane Sandy. The first assumption is that the United States will continue to have a reliance on petroleum as an energy source. Consumer demand for petroleum as a principal energy source validates the importance of petroleum resiliency as articulated by past and current NSS. The second assumption is that mitigating petroleum distribution disruption by way of emergency petroleum supply chains will be an enduring national response effort. Both past and current NSS, the NRF, and other federal publications all seek to generate unified action to mitigate petroleum supply disruption caused by physical threats. The third assumption is that the DOD will continue to play a significant role in DSCA missions to sustain emergency petroleum supply chains. This DOD role proves only true when local, state and federal agencies can

no longer fill disaster response requirements. The fourth assumption is that emergency petroleum supply chains are a sufficient case study to answer the research questions. Within the continuum of emergency supply chains, Hurricane Sandy is an example in which state and federal agencies required DOD support, to bolster existing emergency petroleum supply chains. The fifth assumption is that emergency petroleum supply chains are not an anomaly. Hurricane Katrina is another case of emergency petroleum supply chains being employed (Wombwell 2009, 129). However, the applicability of this case does not reflect the current NRF, which was implemented in 2008 to supersede the *National Response Plan*. Additionally, when Hurricane Sandy made landfall in 2012, it was a tropical storm, unlike the hurricane of 1938 known as the "Long Island Express," which made landfall as a category three hurricane (NWS 2018). Although if a major hurricane were to make landfall in the Northeast again, emergency fuel reserves would be depleted in one to two weeks as indicated by industry experts after Hurricane Irene in 2011 (Phaneuf 2011). Therefore the potential for another "Long Island Express" to make landfall again is difficult to predict, though on average one major hurricane does make landfall once per decade (Van Patten 2010). Even though predicting hurricanes is difficult, the historical context of major hurricanes provides sufficient evidence that they will occur again and cause petroleum supply disruptions. These five assumptions are vital in determining the applicability and feasibility of the study.

Definitions

Catastrophic Incident: "any natural or manmade incident, including terrorism that results in extraordinary levels of mass causalities, damage, or disruption severely

affecting the population, infrastructure, environment, national morale, or government functions" (DHS 2016, 1).

Civil Authorities: "Those elected and appointed officers and employee who constitute the government of the United States, the governments of the 50 states, the District of Columbia, the Commonwealth of Puerto Rico, United States territories, and political subdivisions thereof" (JCS 2013, GL-5).

Defense Support of Civil Authority (DSCA): "Support provided by federal military forces, Department of Defense (DOD) civilians, DOD contract personnel, DOD component assets, and National Guard (NG) forces (when the Secretary of Defense [SecDef], in coordination with the governors of the affected states, elects and requests to use of those forces" (JCS 2013, vii).

Emergency Supply Chains: A process that shares similarities of supply chains, but meets an urgent demand without consideration of cost and forms in response to an emergency. (Shatzkin 2017, 13).

Center of Gravity (COG): "the primary entity that possesses the inherent capability to achieve the objective" (Eikmeier 2010, 158).

Critical Capabilities*:* "those means that are considered crucial enablers for a COG to function as such, and are essential to the accomplishment of the adversary's specified or assumed objective(s)" (JCS 2014, IV-12).

Critical Resources*:* "the conditions, resources, and means that enable a critical capability to become fully operational" (JCS 2014, IV-12).

Critical Vulnerabilities*:* "those aspects or components of critical requirements that are deficient, or vulnerable to direct or indirect attack in a manner achieving decisive or significant results" (JCS 2014, IV-12).

Scope

The study's scope is defined by the agencies and organizations, region, and period that all pertain to events associated with Hurricane Sandy and the subsequent emergency petroleum supply chains. Determining the scope is directed by the research questions which provide a general start point for research. Development of research led to the agencies and organizations associated with emergency petroleum supply chains during Hurricane Sandy that include the DOD, USNORTHCOM, DLA–Energy, the Department of Homeland Security (DHS), FEMA, and the DOE. State level agencies that are of significance to the scope are New York's Office of Emergency Management and New Jersey's Office of Emergency Management, due to their roles in Hurricane Sandy response efforts. As a private sector organization, Foster Fuels, a national fuel distributor, was included in the agencies and organizations associated with Hurricane Sandy. The region covered is defined as the Northeast Region of the United States, comprising of Maine, Vermont, New Hampshire, Connecticut, Rhode Island, Massachusetts, Delaware, Maryland, New York, New Jersey, and Pennsylvania (FEMA 2013, 4). The time period of the case study is from October 26th to December 3rd, 2012 which captures efforts associated with emergency petroleum supply chains (FEMA 2013, 5). These research boundaries provide the participants, region, and time period.

Limitations

Limitations are actions and circumstances which are beyond the control of this study. Even as limiting factors against the development and argument of this thesis, they did not prove to be detrimental. At the start of research, limitations became evident from the professional field of Emergency Management, and policies and procedures associated with emergency petroleum supply chains. The reason why the professional field of Emergency Management was a pre-identified limitation is that it is an evolving profession (Canton 2007, 66). As an evolving profession, it transcends both public and private organizations by leveraging its fundamental tenets and principles in generating unified action to resolve crisis-based incidents through a concerted effort. However, participating actors may view these tenets and principles through different lenses, which can create disparity in how they integrate at both strategic and tactical levels (Canton 2007, 48). The second known limitation upon starting research was policies and procedures concerning emergency petroleum supply chains. Emergency petroleum supply chains incorporate a large number of actors which do not always align their internal systems with external agencies. However, overarching strategic publications such as the NRF do help to mitigate this limitation as discovered through research. With these limitations identified, they proved not to be detrimental during research.

Delimitations

Delimitations are the self-imposed constraints placed on this study. The first delimitation and the most significant is the decision to limit the scope of research to the bounded case study of emergency petroleum supply chains during Hurricane Sandy. The decision to not include other catastrophic incidents which showcased emergency

petroleum supply chains, such as Hurricane Katrina, was based on using the most current information as it relates to today's version of the NRF. Lessons learned from Hurricane Katrina were added to revised versions of the NRF and subsequent disaster response strategies. Therefore, the reasoning for using Hurricane Sandy is to provide the most current context of a catastrophic incident initiating the need for emergency petroleum supply chains. Additionally, Hurricane Sandy presents one of the most current examples in which Federal agencies, to include the DOD and the private sector, combined efforts during emergency petroleum supply chains. The significance of this aspect is how Hurricane Sandy required a whole-of-government response to combat the fuel shortage, and demonstrates the complexity of emergency petroleum supply chains. Secondly, this study focuses on the "last mile" of emergency petroleum supply chains (Decker 2014, 14). The last mile is the final segment where commodities transfer from a distribution node to the point of need (Decker 2014, 14). It is during the last mile of emergency petroleum supply chains where this study will focus its investigation. Thirdly, this study only focuses on the commodity of petroleum rather than other commodities for disaster response. The selection of petroleum was due to its correlation to national security and the stability of the Northeast region during Hurricane Sandy. Together these three delimitations are imposed on the study, to focus the investigation of emergency petroleum supply chains.

Significance

The significance of this study is its approach towards the complexity of emergency supply chains. As an alternative approach, the COG concept is used to analyze the critical factors of emergency petroleum supply chains during Hurricane

Sandy. By doing so, the study provides a median which is transferable to the DOD community and applicable to the DSCA mission. Furthermore, the COG concept can assist the NRF as it leverages the core capability of "Logistics and Supply Chain Management" during disaster response. During disaster response, emergency supply chains are utilized to meet the objective of this core capability, which is the delivery of commodities to the point of need. Overall, the COG concept offers an alternative view towards analyzing the complexity of emergency supply chains, by assessing emergency petroleum supply chains during Hurricane Sandy.

Summary

Emergency supply chains are vital entities of the "Logistics and Supply Chain Management" core capability. One of the key objectives of this core capability is to provide emergency petroleum distribution during catastrophic incidents. However, emergency supply chains possess special characteristics which professional fields are still trying to refine in order to improve their effectiveness. The purpose of this study is to investigate those special characteristics interpreted as the critical factors of emergency petroleum supply chains. To achieve the study's goal, this thesis uses the bounded case study of emergency petroleum supply chains during Hurricane Sandy. Investigating the critical factors of emergency petroleum supply chains asks the following research questions, "What are the critical factors of emergency petroleum supply chains during the Hurricane Sandy?" "How effective was the *National Response Framework* in planning for and managing emergency petroleum supply chains?" "How does this study advance the understanding of emergency supply chains?" Answering the research questions will take an alternative approach towards investigating the special characteristics of

emergency supply chains by using the COG concept. The significance of a COG approach is to provide insight into future DSCA operations and to contribute towards the general understanding of emergency supply chains. As an essential aspect of the NRF's core capabilities, emergency supply chains assist in providing essential services and commodities, such as emergency petroleum distribution.

CHAPTER 2

LITERATURE REVIEW

A review of the relevant literature provides the significance of a petroleum supply disruption and the complexity of responding with emergency supply chains to mitigate the effects. Maintaining a resilient petroleum supply is an essential interest of the NSS, and any disruption to it is a risk. To offset the risk, the mechanism of emergency supply chains is used to conduct emergency petroleum distribution under the supervision of the NRF. As a national framework, the NRF provides the guidelines for how whole-of-government actors will respond to disasters, to include emergency petroleum supply chains. However, emergency supply chains are a challenging endeavor due to their complexity. To understand why they are complex, the COG concept is used to determine the critical factors of emergency petroleum supply chains. These four topics: petroleum supply disruption, emergency supply chains, disaster response, and the COG concept serve as the focus areas for the literature review.

Petroleum Supply Disruption

A man-made or a naturally occurring incident can cause petroleum supply disruptions. Hurricanes are an example of naturally occurring incidents where petroleum supply disruptions can lead to fuel shortages (CBO 2012, 4). Similar to other naturally occurring incidents, tornados, earthquakes, tsunamis, and blizzards all create disruptions. The significance for selecting hurricanes to examine petroleum supply disruptions is their "scalability factor associated with disaster events that fall along a continuum, from small incidents (eg, localized flooding) to widespread catastrophes (eg, a category 5 hurricane)"

(Young and Peterson 2014, 173). Hurricanes Katrina, Irene, and Sandy are all examples of significant hurricane strikes which degraded existing petroleum distribution networks and resulted in petroleum shortages. By producing high sustained winds and wide area flooding, these hurricanes affected petroleum refineries, terminals, pipelines, and ports, all essential aspects of petroleum distribution networks. The disruption to existing petroleum distribution networks serves as the causation for emergency petroleum supply chains.

Petroleum distribution networks are one of the essential energy arteries for the nation (API 2016, 9). Their importance relates to the national security interest of energy security, which is articulated by the NSS (U.S. President 2017, 23). To secure this national security interest, the DHS includes the essential aspects of petroleum distribution networks into the *National Infrastructure Protection Plan* to safeguard them from catastrophic incidents such as hurricanes (DHS 2013, 20). The critical aspects of petroleum distribution networks include physical locations connected through intermodal means. Physical locations include ports, terminals, refineries, and the point of sale. Pipelines, railcars, shipping, and line haul trucks are the intermodal means to connect those physical locations to create petroleum supply chains (API 2016, 10). In total, petroleum supply chains within the United States consist of 144 refineries, 38 US flagged vessels, 3,300 tank barges, 200,000 rail cars, 1,400 terminals, 100,000 line haul trucks, and 200,000 miles of pipeline as of 2013 (NACS 2013, 13). The significance of petroleum supply chains is how they relate to the national security interest of energy security. Once an area is disrupted by a catastrophic incident, as with hurricanes, emergency petroleum supply chains are employed to mitigate the effects of petroleum

supply disruptions. Hurricanes Katrina, Irene, and Sandy were able to disrupt petroleum supply chains by degrading ports, terminals, refineries, and the point of sale.

Refineries are essential parts of petroleum supply chains and were affected by hurricanes Katrina, Irene, and Sandy. At refineries, crude oil is received from one of the intermodal means and converted into a desired petroleum product. From a 42 gallon barrel of crude oil, a refinery will convert roughly 20 gallons into gasoline, 12 gallons into diesel fuel, 4 gallons into jet fuel, and the rest converted to demand-based products (EIA 2016). During Hurricane Sandy, roughly 7% of the Nation's refining capacity was affected, which correlates to 1.29 million barrels a day (NACS 2013, 65). The disruption caused by Hurricane Sandy closed two refineries and forced four others to reduce their refining capacity. This reduced refining capacity lasted nearly a month, resulting in a daily loss of 290,000 barrels of fuel (DOE 2013, 15). Hurricane Irene's disruption did not last as long as Hurricane Sandy's, although it had a greater reduced refining capacity of 416,000 barrels per day (DOE 2013, 15). The effects of Hurricane Katrina saw 11 refiners shut down with a combined refining capacity of 2.2 million barrels a day (DOE 2009, 21). Refining capacity did not return to normalcy until two months after the Hurricane Katrina made landfall (DOE 2009, 22). The damage these hurricanes had on refineries significantly disrupted petroleum supply chains and resulted in fuel shortages (DOE 2013, 14).

Fuel shortages created by the effects of Hurricane Katrina, Irene, and Sandy had the secondary effects of closing retail fuel locations, impacting petroleum price, generating consumer anxiety, and fuel rationing. In the days after Hurricane Katrina, the price of gasoline jumped by 40 cents a gallon on average across the Nation (Bernhard

2005). The increased price of gasoline was a result of refinery closures in the Gulf of Mexico region, which Hurricane Katrina affected. However, during Hurricanes Sandy and Irene, gasoline and diesel prices remained about the same from pre-storm through post-storm (DOE 2013, 24). One interpretation of why fuel prices increased during Hurricane Katrina and not during hurricanes Irene and Sandy is that Hurricane Katrina affected more of the Nation's refining capacity than the other two hurricanes did. Additionally, during Hurricane Irene, there were no widespread closures of fuel retail locations as there were with Hurricane Katrina and Sandy (DOE 2013, 24). In the aftermath of Hurricane Sandy, over one-third of all retail fuel locations in the greater New York Metropolitan area, to include New Jersey and western Connecticut, were closed (DOE 2013, 24). Due to a large majority of retail locations closed, the ones with fuel saw extended consumer lines, which elevated consumer anxiety about gasoline availability (Burk and McNeil 2015, 35). To manage the fuel shortage caused by Hurricane Sandy, the Mayor of New York City implemented fuel rationing that lasted through November of 2012, nearly a month after Hurricane Sandy made landfall (Gibbs and Holloway 2013, 21). Due to widespread fuel shortages caused by Hurricanes Katrina and Sandy and the national media coverage these fuel shortages were receiving, the Federal government took a larger role in mitigating fuel shortages than was taken during Hurricane Irene. Additionally, Hurricane Sandy made landfall just before the presidential elections, which drove the Federal government to take a more assertive role in conducting emergency petroleum supply chains than during hurricanes Katrina and Irene (Burk and McNeil 2015, 37, 62).

Of three fuel shortages caused by Hurricanes Katrina, Irene, and Sandy, Irene's was the least significant, since petroleum prices remained consistent and a large majority of retail fuel locations remained open. Hurricane Katrina's was the most substantial since it affected the price of fuel at a national level and a significant amount of the Nation's refining capacity. However, Sandy's fuel shortage received the most aggressive response by the Federal government through emergency petroleum supply chains. These emergency petroleum supply chains leveraged both private sector and military transportation assets to distribute petroleum more so than Hurricane Katrina. All three storms depict the importance of petroleum supply resiliency and how a disruption to petroleum supply chains can have significant effects.

Emergency Supply Chains

Emergency supply chains are a relatively new concept with linkages to the established understandings of supply chain management (Yong and Peterson 2014, 171). While different terms define emergency supply chains, such as emergency logistics or humanitarian supply chains, there are similar themes used to describe emergency supply chains. These themes provide the characteristics of what emergency supply chains are and how they differ from commercial supply chains.

One theme that genuinely differentiates emergency supply chains from commercial supply chains is that emergency supply chains occur during disasters (Shatzkin 2017, 10). What makes this difference significant is that disasters cripple infrastructure, incapacitate local and state governments, and existing commercial supply chains (Canton 2007, 45-46). By doing so, the need for emergency supply chains to rapidly deliver life-saving resources and capabilities is of necessity. It is the environment

created by a disaster which requires the use of emergency supply chains, due to the onset of the disaster and its effects (Yong and Peterson 2014, 171). In providing commodities, emergency supply chains share similar attributes of commercial supply chains such as "manufacturing, distribution, and retail," though differ as emergency supply chains seek to mitigate the effects of a disaster rather than "meeting a general demand" as commercial supply chains do (Shatzkin 2017, 12). Recognizing this key difference between these two supply chains is essential towards understanding the characteristics of emergency supply chains.

Framing emergency supply chains encompasses various aspects and characteristics that are only applicable to emergency supply chains and not commercial supply chains. Richard Young and Matthew Peterson in their work *Emergency Management Logistics Must Become Emergency Supply Chain Management* assign five variations for defining emergency supply chains.

> 1. Unpredictability of demand insofar as timing, location, type, and size are concerned.
>
> 2. Suddenness of occurrence of demand on a large scale, with very short lead times for a wide variety of materials.
>
> 3. High stakes-especially with human lives-associated with timely deliveries.
>
> 4. Compromised logistics infrastructure.
>
> 5. A general lack of resources, specifically supplies, trained personnel, technology, transportation capacity, and money. (Young and Peterson 2014, 171).

These variations between emergency supply chains and commercial supply chains all trace back to the environment created by a disaster. Scope and scale of the disaster, whether it be limited or catastrophic, is not of significance, since their variations seek to view emergency supply chains holistically for any disaster.

Echoing these variations between emergency supply chains and commercial supply chains, Guojun Ji and Caihong Zhu offer similar aspects to characterize emergency supply chains. In their work A Study on Emergency Supply Chain and Risk-Based on Urgent Relief Services in Disasters, Ji and Zhu address the historical precedent of emergency supply chains. Referencing the 2004 Asian Tsunami, 2005 Hurricane Katrina, and 2008 Sichuan earthquake in China, they stress the importance of emergency supply chains in providing the vital "lifeline" after these disasters (Ji and Zhu 2012, 313). Tracing back to the environment created by a disaster as the causation for emergency supply chains, they characterize them as:

> 1. The urgent relief services are very diverse and urgent.
>
> 2. Accurate and real-time urgent relief demand information is almost inaccessible.
>
> 3. The benefits of emergency logistics operations are always weakened.
>
> 4. Government and the market participants in the emergency logistics service together. (Ji and Zhu 2012, 314).

These characteristics help to distinguish emergency supply chains from commercial supply chains, much like Young and Peterson's variations, however, Ji and Zhu's characteristics also speak to the complexity and challenges associated with emergency supply chains. Of significance is their second point regarding accurate and real-time information which can have a ripple effect up and downstream of emergency supply chains, and is similar to Young and Peterson's first point. Their fourth point concerning government and private sector interoperability is of importance due to its linkages to the NRF and the DSCA mission. Using historical examples to promote the importance of emergency supply chains, Ji and Zhu characterize how dynamic and complex emergency supply chains can be.

As an emerging concept that is growing in importance with each catastrophic event, the purpose of emergency supply chains is to cultivate life-saving resources and capabilities by bringing them to the point of need and care. Due to their complexity, Young and Peterson argue pre-emptive actions for emergency supply chains during the prepare phase of incident support. These actions and activities include determining requirements, assessing capabilities, mitigating shortfalls, and establishing command and control systems (Young and Peterson 2014, 186). By defining the variations between emergency supply chains and commercial supply chains, they also provide the context for what emergency supply chains are.

Disaster Response

The NRF provides unifying principles and concepts to integrate federal, state, and local governments alongside private and non-private organizations for disaster response. As a framework, the NRF defines the planning process, the core capabilities to be leveraged, the emergency support functions to coordinate efforts and its relationship to the National Incident Management System (NIMS). NIMS supports the NRF by constructing uniformed "command and management structures" where all participants are included to galvanize unity of effort (DHS 2016, 3). During Hurricane Sandy, each of these disaster response aspects were applied to execute emergency petroleum supply chains. As a unifying document, NRF sets out to orchestrate disaster response through it's planning process.

The purpose of disaster response planning is to provide guidance and direction for participating organizations (DHS 2016, 47). In doing so, the planning process is influenced by several principles which are articulated by FEMA's *Developing and*

Maintaining Emergency Operations Plans: Comprehensive Preparedness Guide (CPG) 101. Key principles are "flexibility," "anticipation," and "inclusiveness" as they relate to emergency petroleum supply chains (FEMA 2010, 1-1). The NRF outlines the planning process as a six-step methodology. The first step of the process begins with establishing a planning team. This step applies the principle of inclusiveness to represent the equities of all agencies. The second step is assessing the situation within the context of disaster response. A key aspect of disaster response is anticipating the environment where disaster response activities will occur. The third step is to identify goals and objectives associated with disaster response to facilitate the fourth step of developing a plan. Finally, step five is approving the plan, followed by maintaining the plan during step six. Used primarily at the operational level, the six-step planning process also encompasses the strategic level, where federal agencies integrate efforts through emergency support functions to establish a Federal Interagency Operational Plan.

Emergency Support Functions (ESF) are a deliberate technique to "bundle and manage" resources and capabilities across the disaster response spectrum (DHS 2016, 33). A total of fourteen ESFs are predetermined by the NRF to help facilitate a coordinated effort. Of significance to emergency petroleum supply chains are *ESF 3: Public Works and Engineering* and *ESF 12: Energy*, as they relate to emergency petroleum distribution. To facilitate the coordination of bundling and managing resources, the NRF also identifies a lead agency that is the proponent for an ESF. For *ESF 3* the lead agency is the DOD, and for *ESF 12* the lead agency is the DOE (DHS 2016, 34). Each ESF has assigned goals to orient the direction of planning. As *ESF 3* and *ESF12* relate to emergency petroleum supply chains, the goals are to coordinate with the

energy industry, restore energy services, and assess energy infrastructure for repair (DHS 2016, 36). By bundling resources into EFS, the NRF can leverage core capabilities during disaster response.

Core capabilities are the essential activities of ESFs during disaster response (DHS 2016, 20). Of the 15 core capabilities, ESFs align with particular core capabilities that support the bundled resources of a specific ESF. For *ESF 12 Energy*, due to its importance with emergency petroleum distribution, it leverages the core capability of "Logistics and Supply Chain Management." The objective of this core capability is to:

> Deliver essential commodities, equipment, and service in support of impact communities and survivors, to include emergency power and fuel support, as well the coordination of access to community staples. Synchronize logistics capabilities and enable the restoration of impacted supply chains. (DHS 2016, 25)

As reviewed earlier, hurricanes Katrina, Irene, and Sandy disrupted petroleum supply chains to varying degrees, with Hurricane Sandy creating a significant fuel shortage. Due to the fuel shortage, the core capability of "Logistics and Supply Chain Management" was leveraged by *ESF 12 Energy*, by conducting emergency petroleum supply chains. Conducting emergency petroleum distribution is a vital aspect of this core capability since it delivers the essential commodity of petroleum to the point of need, while allowing commercial petroleum supply chains to return to normalcy. As vital entities of *ESF 12 Energy*, emergency petroleum supply chains are planned and managed through the guidelines of the NRF. To investigate *ESF 12 Energy's* application of emergency petroleum supply chains during Hurricane Sandy, the COG concept is the analytical approach.

Center of Gravity (COG)

An alternative perspective in which to investigate the complexity of emergency supply chains is the COG approach. The COG concept is both a planning tool and an entity's source of power, which orients capabilities and resources towards an objective. As a planning tool it is "one of the most important tasks confronting the JFC's staff during planning and analyzing friendly and adversary COGs" (JCS 2017, IV-23). Joint military doctrine emphasizes the importance of "analyzing friendly" COGs, and because of this importance the COG concept is selected as an analytical tool. Applying the COG concept to analyze emergency petroleum supply chains aims to reduce their complexity by understanding their composition. A COG analysis will determine an entity's composition by identifying the critical factors known as critical capabilities, critical requirements, and critical vulnerabilities. Using the COG concept is not a new way of assessing problems within the context of Homeland Security, as MAJ Lisa Noel's *Bridging the Gap: Department of Defense's Planning For Domestic Disaster Planning* and MAJ Jeffrey Britton's *A logistical Response to Assist in Answering the Call of Defense Support of Civilian Authorities in Disaster Response* referenced it in their studies. As a way to assess the critical factors of emergency petroleum supply chains, the COG concept can be used to explore the proposed research questions.

Joint Publication (JP) 5-0 Joint Planning is an authoritative DOD document regarding the COG concept. In conjunction with *JP 2-01.3 Joint Intelligence Preparation of the Operational Environment*, it provides the doctrinal foundation for what a COG is and how it is an analytical planning tool for the United States Military. Together these publications provide the significance, characteristics, factors, and its application towards

military planning. However, even as an essential element of operational design, it is arguably one of the most confusing and debated concepts in United States Military doctrine (Pattee 2012, 117). Due to its importance, *JP 5-0* stresses the significance of determining both friendly and adversary COGs for military planning, which can include DSCA operations.

JP 5-0 defines a COG as "a source of power that provides moral or physical strength, freedom of action, or will to act" and emphasizes its connection to an objective (JCS 2017, IV-23). Derived from 19th century Prussian Army staff officer Carl Von Clausewitz, it has become an essential element of operational art and design for military planners. Current COG doctrine traces its lineage back to its first introduction in 1986's *Field Manual (FM) 100-5 Operations* that defined the COG as the "source of strength or balance" (HQDA 1986, 10). This initial understanding of the COG concept is from Howard and Paret's 1976 translation of Clausewitz's unfinished work *On War*. However, the translation misinterpreted the German word "schwerpunkt" which means the "weight of focus or point of effort" for the term center of gravity, which in German is "gravitationpunkit" (Eikmeier 2012, 136). Although, it is Clausewitz's COG definition of "the hub of all power and movement, on which everything depends" that drove the concept into prominence within United States Military doctrine (Clausewitz 1976, 596-97). Today's doctrinal definition of the COG concept and its associated factors still raises confusion and debate, since many recognize the importance of the concept but argue on how to define it properly (Eikmeier 2010, 156). Beyond the current definition of the concept, United States Military doctrine also provides definitions for the critical factors associated with it.

Dr. Joe Strange first introduced the critical factors of critical capabilities, critical requirements, and critical vulnerabilities in his work *Centers of Gravity & Critical Vulnerabilities: Building on the Clausewitzian Foundation So That We Can All Speak the Same Language* (Strange 1996, 2). The critical factors are intended to build on *FM 100-5*'s understanding of the COG concept to provide military planners a methodology to determine an entity's COG. *JP 5-0* provides the following definitions for critical capabilities, critical requirements, and critical vulnerabilities:

> Critical capabilities are the primary abilities essential to the accomplishment of the objective. Critical requirements are essential conditions, resources, and means the COG requires to perform the critical capability. Critical vulnerabilities are those aspects or components of critical requirements that are deficient or vulnerable to direct or indirect attack in a manner achieving decisive or significant results. (JCS 2017, IV-25).

JP 5-0's definition of critical capabilities closely mirrors Dr. Strange's original definition which is the "primary abilities which merits a COG to be identified as such in the context of a given scenario, situation or mission" (Strange 1996, 43). Therefore, within a system, whether it be friendly or an adversary, it may possess many critical capabilities to achieve its goal. Where the two definitions differ is their identification of the COG within the collection of critical requirements. Dale Eikmeier supports Dr. Strange's approach by articulating "the center of gravity is the primary entity that inherently possesses the critical capabilities to achieve the objective" (Eikmeier 2010, 156).

However, when assessing the critical factors of a system, current United States Military doctrine does not provide a framework to validate whether the identified critical requirement is truly the COG. To supplement JP 5-0, Eikmeier provides additional input by providing the "Doer and Used" test, which is applied against each critical requirement of the system to determine the correct COG (Eikmeier 2010, 157). He states the "doer" is

the critical factor which meets the criteria for achieving the objective and therefore, the COG of a system (Eikmeier 2010, 157). The other critical requirements fall into the "used" category, which contributes to or is used by the COG to achieve the objective (Eikmeier 2010, 157).

As indicated by JP 5-0's definition, the critical requirements of a system are those "resources and means" the COG uses to achieve the system's objective. Again, not to be confused with critical capabilities that are "used" by the COG, critical requirements are the nouns leveraged by critical capabilities. To further explain the differences between critical capabilities and critical requirements, Eikmeier applies the "ends, ways, and means" methodology. In this methodology, he defines critical capabilities as "ways" in which the system will accomplish its objective or "ends," and critical requirements are the "means" or resources to achieve it (Pattee 2012, 120). Once critical requirements are determined, the critical vulnerabilities of them are isolated to affect an adversary COG from accomplishing its objective or protect a friendly COG to accomplish its objective.

Seen as nouns, Strange's definition of critical vulnerabilities are "critical requirements or components thereof which are deficient, or vulnerable to neutralization, interdiction or attack (moral/physical harm) in a manner achieving decisive results" (Strange 1996, 3). His definition is virtually left unchanged and adopted by US military doctrine within JP 5-0. Critical vulnerabilities are the agents of change to modify an adversary or to protect a friendly COG. Since critical vulnerabilities are the weaknesses of critical requirements, their degradation or disruption can alter the COG's ability to achieve the system's objective.

To conceptualize the entire "ends, ways and means" methodology by way of identifying a system's COG and critical factors, Dale Eikmeier provides the following construct.

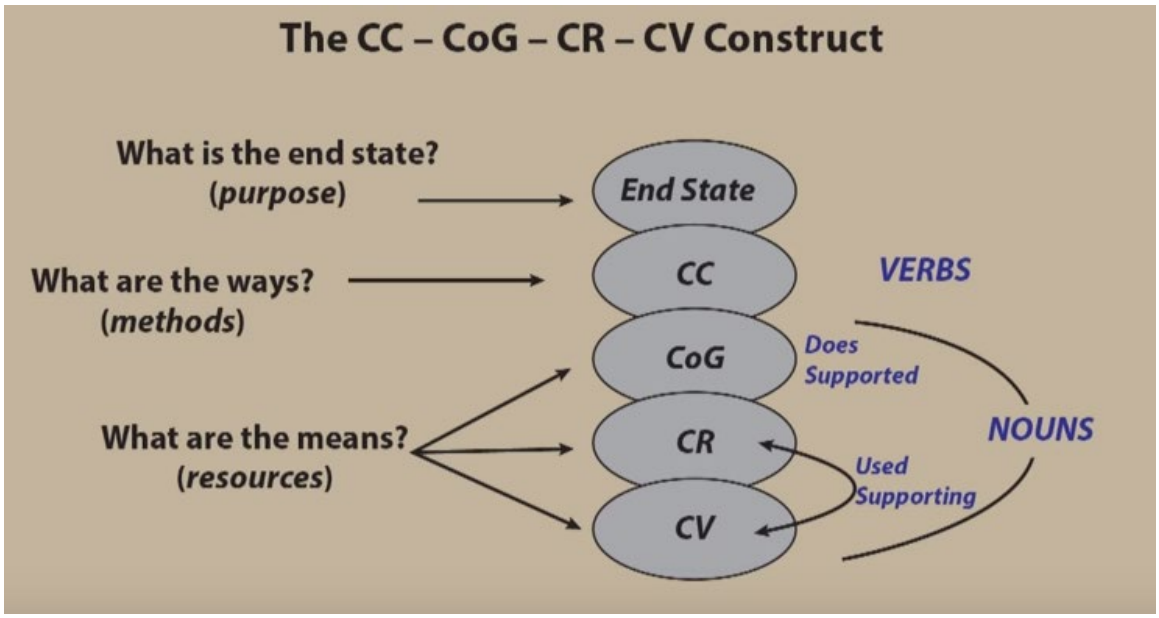

Figure 1. Center of Gravity

Source: U.S. Army Command and General Staff College, "Operational Art, Design and the Center of Gravity Pt. 4 of 4," 2015, Dale Eikmeier discusses operational art, operational design and center of gravity, published 13 October, YouTube, accessed January 20, 2018, https://www.youtube.com/watch?v=-RYbtyzfB1w.

Eckmeier's construct is one methodology in determining a system's COG. This methodology is more informative than one provided by United States Military doctrine, which provides the tool of "visualization" to determine a COG (JCS 2014, IV-11). To "visualize" the COG, *JP 2-01.3 Joint Intelligence Preparation of the Operational Environment* offers characteristics that are likely to be associated with it. These characteristics indicate that a COG can exist at each level of war, and is a "source of

power" that may change and alter due to critical vulnerabilities being affected (JCS 2014, IV-11). Additionally, this publication articulates that a COG could be a system comprising of nodes, links, and functions; meaning it could be a system within the system (JCS 2014, IV-11). By applying a systems perspective towards the COG concept, planners can understand the actors, relationships, and interdependencies of a system, by viewing them as links and nodes. (JCS 2014, I-4). As a mutually supporting framework to the COG concept, a systems perspective will help to visualize an entity, whether friendly or an adversary, and "describe" the COG itself (Eikmeier 1998, 38).

Understanding the COG concept is an essential part of this study. By applying the COG concept to emergency petroleum supply chains, it will determine their critical factors and COG. Analyzing emergency petroleum supply chains through the COG construct will provide an alternative perspective in assessing a certain type of emergency supply chains that are petroleum based. The goal of the COG analysis is to contribute towards the larger discussion regarding the complexity of emergency supply chains.

Summary

Four key topics concerning emergency petroleum supply chains form the basis for understanding the use of the COG construct to explore emergency petroleum supply chains. The first topic focuses on petroleum supply disruption to highlight the necessity for emergency petroleum supply chains. The second topic describes the mechanism for responding to petroleum supply disruptions through the use of emergency supply chains. The complexity of emergency supply chains presents challenges related to the implementation of emergency petroleum supply chains, which are key to note during planning. The third topic explores the way in which disaster response is managed through

the NRF by leveraging planning processes, ESFs, and core capabilities. The final topic develops an understanding and context regarding the COG concept. The purpose of providing context is to introduce the concept before implementing it as the approach to investigate emergency petroleum supply chains.

CHAPTER 3

RESEARCH METHODOLOGY

Introduction

Qualitative research through a case study approach is used to investigate the complexity of emergency petroleum supply chains. In addition, this methodology provides the framework for collecting and organizing data. The process of collecting and organizing data links to the COG construct for the study's analysis of emergency petroleum supply chains. Analyzing emergency petroleum supply chains through the COG construct is explained through the "ends, ways, means" technique. As a final component of the methodology, it is important to establish the reliability and validity of this methodology to authenticate the analysis of emergency petroleum supply chains.

Research Design

The research design of this study uses a qualitative methodology through a case study approach. Qualitative research enables the examination of emergency petroleum supply chains within a given context from a holistic perspective (Creswell 2007, 40). The case study approach provides a given framework to address the phenomenon of emergency petroleum supply chains (Merriam 2009, 40). Together, the design methodology of a qualitative investigation through a case study approach supports the research questions of (1) "What are the critical factors of emergency petroleum supply chains?" (2) "How effective was the *National Response Framework* in planning for and managing emergency petroleum supply chains?" and (3) "How does this study advance the understanding of emergency supply chains?"

Problem and Assumption

The research approach starts with first identifying the topic problem and critical assumption. Emergency supply chains are a complex phenomenon which are essential aspects of disaster response (Thomas and Kopczak 2005, 2). Due to their complexity, understanding the composition of emergency supply chains presents a problem set for practitioners in how best to employ them during catastrophic events (Young and Peterson 2014, 173). The critical assumption is that emergency supply chains will be an enduring requirement of disaster response during catastrophic events (Thomas and Kopczak 2005, 13). Since the assumption rests on the phenomenon re-occurring, the goal of reducing its complexity is the basis for this study's qualitative investigation.

Qualitative Research

A qualitative investigation is conducted "to understand the contexts or settings in which participants in a study address a problem or issue" (Creswell 2007, 40). Sharan Merriam, in her work *Qualitative Research*, describes four key characteristics of qualitative research. The first characteristic is "focus of meaning and understanding" which pertains to gaining a holistic understanding of a phenomenon (Merriam 2009, 14). "Researcher as the Primary Instrument" is the second characteristic, which places the researcher at the focal point of the study (Merriam 2009, 15). As the focal point, the researcher is essential towards accomplishing the goal of the research, but also a weakness due to human biases and cognitive traps (Thomas and Rielly 2017, 2). The third characteristic of a qualitative investigation is "an inductive process," where the researcher collects data to analyze it (Merriam 2009, 16). The "Rich description" is the final characteristic, which provides a narrative report of the analytical findings (Merriam

2009, 16). The goal of qualitative research is to address "a problem or issue" that needs to be "explored" (Creswell 2013, 47). This coincides with the goal of reducing the complexity of emergency petroleum supply chains, thus supporting the use of the qualitative methodology.

Qualitative Research Approaches

Creswell, in his work *Qualitative Inquiry & Research Design*, offers five approaches towards qualitative research. As the basis for selecting a qualitative research approach, Creswell offers "narrative," "phenomenological," "grounded theory," "ethnographical," and "case study" as qualitative research approaches (Creswell 2007, 10). Reviewing each approach from different perspectives, to include Creswell's, determines which research approach is most applicable towards answering the research questions of this study.

A "narrative" approach focuses on a phenomenon to discover how an individual and collective groups interacted with a phenomenon through experiential stories (Patton 2002, 115). Since a narrative approach focuses on the reflections of those who experienced a phenomenon, it does not suit the research approach needed to address the problem of emergency petroleum supply chains. The goal of the research is to understand the critical factors of emergency petroleum supply chains, not experiences from them.

The "phenomenological approach follows a narrative methodology but seeks to discover "the essence or basic structure of experience" with a phenomenon (Merriam 2009, 25). In a similar argument as to why a narrative approach is not applicable, the goal of this study does not relate to experiences with emergency petroleum supply chains.

A “grounded theory” approach applies a rigorous methodology to generate theoretical ideas and a theory for a phenomenon (Schwandt 2007, 131). As a methodology that produces a theory grounded in data, this approach is not applicable to emergency petroleum supply chains, as the case study is not theory-based.

An “ethnographical” approach seeks to understand the characteristics of “human society and culture” and within that culture, its “beliefs, values, and attitudes” (Merriam 2009, 27). The ethnographical approach towards studying emergency petroleum supply chains is not applicable because the purpose of this study is to understand the critical factors, not cultural factors.

A “case study” approach researches a phenomenon within a “bounded system” (Creswell 2013, 97). The “bounded system” fences the phenomenon within time and space to help the researcher study it more precisely (Merriam 2009, 40). Moreover, a case study approach is applicable when the researcher “has limited control over events being studied when the object of study is a contemporary phenomenon in a real-life context, and when it is desirable to use multiple sources of evidence” (Schwandt 2007, 28). The goal of a case study approach is to understand the problem of the case itself. Therefore, the case study approach is selected to investigate emergency petroleum supply chains.

Reseach Approach Selection

Of the five approaches towards qualitative research, a case study approach agrees with the aspects of this study. First, the problem and assumption identified with the phenomenon of emergency petroleum supply chains addresses a real-life issue which the researcher has no control over. Second, as a complex problem, studying emergency petroleum supply chains requires multiple sources to validate evidence through

triangulation. Third, a "bounded system" helps define and bracket the problem of emergency petroleum supply chains for the researcher. The use of a case study approach contributes to the quality of research.

Data Collection

Data collection begins with a purposeful sampling of documentation. Creswell describes purposeful sampling as a strategy to gather an all-inclusive perspective regarding the research problem (Creswell 2007, 129). Merriam contributes to the definition of purposeful sampling by explaining it's variations as "typical," "unique," "maximum," "convenience," and "network" (Merriam 2009, 78). Of the five sampling variations, network "is perhaps the most common form of purposeful sampling" (Merriam 2009, 79). "Network" sampling, as a method for purposeful sampling, takes the established limitations and delimitations placed on the research to locate data. Setting "boundaries," such as the limitations and delimitations imposed on the research, helps frame the aspects of it and focus data collection (Miles, Huberman, and Saldana 2014, 31). Data is found in the forms of interviews, observations, audiovisual materials, and documents (Creswell 2007, 129). Collected data from documents is scrutinized to ensure authenticity and applicability by identifying potential biases, perspective, and source (Miles, Huberman, and Saldana 2009, 151). Purposeful sampling through the technquie of "network" provides the construct for data identification.

The technique of "network" sampling starts by identifying aspects that initially relate to the problem of emergency petroleum supply chains (Merriam 2009, 79). As sampling continues, the "network" methodology enables the first aspects of research to refer to other significant forms of data to generate the depth of knowledge required. To

prevent data collection deviation, the limitations and delimitations imposed on this study also support the sampling strategy. A coding system is used to organize data collected from purposeful sampling.

Coding

Coding is "used to retrieve and categorize similar data chunks so the researcher can quickly find, pull out, and cluster the segments relating to a particular research question" (Miles, Huberman, and Saldana 2014, 72). Coding for this study begins with predetermined codes that are guided by the research questions. Additionally, coding ties back into the purposeful sampling technique of "network" by associating the predetermined codes with the first identified aspects of the research problem. Creswell defines this process as "open coding" to determine the significant categories of data (Creswell 2007, 64). The predetermined codes for this study are "Federal Response," "Hurricane Sandy," "Defense Support of Civil Authorities," "Petroleum," and "Emergency Petroleum Supply Chain." The significance of these codes is their definitions. Code "definitions are indispensable so they can be applied consistently by a single researcher over time" (Miles, Huberman, and Saldana 2014, 84). Definitions for the listed codes are:

> Federal Response (FR): Federal and state organizations, relationships, and functions relating to Hurricane Sandy.
>
> Hurricane Sandy (HS): Chronological events relating to the FR code during Hurricane Sandy.
>
> Defense Support of Civil Authorities (DSCA): Department of Defense specific roles and functions.
>
> Petroleum (P): Economic impacts and effects of petroleum distribution disruption during Hurricane Sandy.

Emergency Petroleum Supply Chains (EPSC): The employment, characteristics, and composition of emergency petroleum supply chains.

The goal of open coding or first cycle coding "is a way to initially summarize segments of data" gathered during purposeful sampling (Miles, Huberman, and Saldana 2014, 86). Additionally, open coding assists with framing the review of the applicable literature. Once open coding is complete, the second stage of coding is axial coding. "Axial coding emerges in which the researcher identifies one coding category to focus on (called the "core" phenomenon), and then goes back to the data and creates categories around this core phenomenon" (Creswell 2007, 64). Of the codes determined for this research, the "core" code of "emergency petroleum supply chains" is the phenomenon. To establish new codes during axial coding or "second cycle coding," the goal is to group similarities between the first set of codes into smaller groupings (Miles, Huberman, and Saldana 2014, 86). The second set of codes, like the first set of codes, is also guided by the research questions. Axial codes for the second cycle of coding are "critical capabilities," "critical requirements," and "critical vulnerabilities." These axial codes were selected to facilitate a COG analysis of emergency petroleum supply chains. Definitions for the axial codes are:

Critical capabilities (CC): "Those means that are considered crucial enablers for a COG to function as such, and are essential to the accomplishment of the adversary's specified or assumed objective(s)" (JCS 2014, IV-12).

Critical requirements (CR): "The conditions, resources, and means that enable a critical capability to become fully operational" (JCS 2014, IV-12).

Critical vulnerabilities (CV): "Those aspects or components of critical requirements that are deficient, or vulnerable to direct or indirect attack in a manner achieving decisive or significant results" (JCS 2014, IV-12).

The axial codes refine data into categories that are applicable for analysis and relate back to the first research question which asks, "What are the critical factors of emergency petroleum supply chains?" Critical factors as axial codes are also essential aspects for a COG analysis, which comprises of critical capabilities, critical requirements, and critical vulnerabilities. Additionally, by using open and axial coding, the codes enable concurrent analysis while collecting data (Miles, Huberman, and Saldana 2014, 70). This data collection methodology, which employs coding to organize data into manageable sets, allows the refinement of information into the categories of critical factors to conduct a COG analysis of emergency petroleum supply chains.

Center of Gravity (COG) Analysis

JP 5-0 defines a COG as "a source of power that provides moral or physical strength, freedom of action, or will to act" and emphasizes its connection to an objective (JCS 2017, IV-23). As an analytical planning tool, the COG concept is being used to understand emergency petroleum supply chains by discovering their source of power. The COG analysis intends to remove the complexity of emergency petroleum supply chains by understanding their critical factors. As an accepted analytical process, the COG concept is also applied by MAJ Lisa Noel's *Bridging the Gap: Department of Defense's Planning For Domestic Disaster Planning* and MAJ Jeffrey Britton's *A logistical Response to Assist in Answering the Call of Defense Support of Civilian Authorities in Disaster Response*.

Eikmeier's approach for a COG analysis leverages the "ends, ways, and means" methodology as a framing technique. In the context of emergency petroleum supply chains, "ends" frames "what is to be accomplished" (Springer 2017, 5). "Ways" frames

"how the ends are to be accomplished" by emergency petroleum supply chains and the "means" frames "with what" (Springer 2017, 5). Eikmeier offers the following steps for a center of gravity analysis, framed by "ends, ways, and means."

> Step 1: Identify the organization's desired ends or objectives.
>
> Step 2: Identify the possible "ways" or actions that can achieve the desired ends. Select the way(s) that the evidence suggests the organization is most likely to use. Remember: Ways are actions and should be expressed as a verb. Then select the most elemental or essential action – that selection is the critical capability. Ways = critical capabilities.
>
> Step 3: List the organization's means available or needed to execute the way/critical capability.
>
> Step 4: Select the entity (noun) from list of means that inherently possesses the critical capability to achieve the end. This selection is the center of gravity. It is the doer of the action that achieves the ends.
>
> Step 5: From the remaining items on the means list, select those that are critical for execution of the critical capability. These are the critical requirements.
>
> Step 6: Complete the process by identifying those critical requirements vulnerable to adversary actions (Eikmeier 2010, 158).

Eikmeier's COG methodology is adopted by first identifying the desired end or objective of emergency petroleum supply chains. Steps two, three, five, and six are initiated during axial coding and expanded upon during analysis (Miles, Huberman, and Saldana 2014, 70). Step four identifies the actual COG (source of power) for emergency petroleum supply chains by applying the "Doer and Used test" of its critical requirements (Eikmeier 2010, 157). The framework of the "Doer and Used" test is:

> Doer:
>
> 1. Only the center of gravity is inherently capable of achieving the purpose or objective.
>
> 2. If something executes the primary action(s) (capability) that achieves the objective, it is the COG.

3. The COG executed the action and used or consumes resources to accomplish it.

Used:

1. If something is used or consumed to execute the primary action (capability), it is a requirement.

2. If something contributes to, but does not actually perform, the action, it is a requirement, not a COG (Eikmeier 2010, 157).

The importance of the "Doer and Used" test is to accurately identify the COG of emergency petroleum supply chains from the list of critical requirements. As the COG, it provides the source of power for emergency petroleum supply chains to achieve their objective.

Validity

Validity is one of the essential criteria of qualitative research. However, its importance is convoluted by the varying ways methodologists approach the concept of validity with non-standard terms and definitions (Merriam 2009, 212). *The Sage Dictionary of Qualitative Inquiry* states "validity is a property of a statement, argument, or procedure. To call one of those things valid is to indicate that is sound, cogent, well grounded, justifiable, or logically correct" (Schwandt 2007, 309). Chava Frankfort-Nachmias and David Nachmias offer another perspective of validity by stating "Validity is concerned with the question "Am I measuring what I intended to measure?" (Frankfort-Nachmias and Nachmais 2000, 149). Additionally, Creswell addresses validity or "validation" as an "attempt to assess the "accuracy" of the findings, as best described by the researcher" (Creswell 2013, 249). Staying with Creswell's definition of validity, he offers the strategy of triangulation to justify the validity of qualitative research.

Triangulation is the process of using "multiple and different sources, methods, investigations, and theories to provide corroborating evidence" (Creswell 2013, 251). For this study, data collection encompassed multiple sources of information, which include authoritative publications, scholarly journals, and news articles. Creswell goes on to state that when "researchers locate evidence to document a code or theme in different sources of data, they are triangulating information and providing validity to their findings" (Creswell 2013, 251). By using open and axial coding during data collection for this study, triangulation is used to support data validation. As an essential criterion of qualitative research, validity speaks to the study's accuracy.

Reliability

Reliability holds the same degree of importance as validity for qualitative research and suffers from the same problem (Merriam 2009, 212). The Sage Dictionary of Qualitative Inquiry states the reliability of an argument "is judged to be reliable if it is capable of being replicated by another inquirer" (Schwandt 2007, 262). The act of replication is the ability of another researcher to duplicate the study with similar results based on the prescribed methodology of the original researcher (Davies 2007, 241). To enable the replication of a study, the original researcher can use an "audit trail" technique. "An audit trail in a qualitative study describes in detail how data were collected, how categories were derived, and how decisions were made throughout the inquiry" (Merriam 2009, 223). The degree of describing the audit trail translates to how well an independent reader can follow the prescribed methodology and determine its reliability. For this study, an audit trail is developed by presenting the research

methodology, data collection process, and how the COG concept will analyze emergency petroleum supply chains to provide reliability.

Summary

A qualitative methodology with the use of a case study explores the complexity of emergency supply chains. The problem and assumption linked to emergency petroleum supply chains during Hurricane Sandy guide the methodology and approach of the study. Collecting and organizing data is accomplished by purposeful "network" sampling and coding. The techniques used to collect and organize data support the framework of a COG analysis. Outlining this research process provides the study's reliability and validity.

CHAPTER 4

ANALYSIS

Introduction

Analytical procedures of the COG concept are used to investigate the critical factors of emergency petroleum supply chains. The purpose for analyzing emergency petroleum supply chains through the COG construct is to determine how resources were committed against requirements to achieve objectives during Hurricane Sandy and to determine whether it is an appropriate planning tool for future DSCA operations. Additionally, as an alternative approach towards reducing the complexity of emergency supply chains, the COG concept can contribute towards the professional discussion regarding emergency supply chains. The analysis can illuminate the critical capabilities, critical requirements, and critical vulnerabilities, known as the critical factors of an entity. For the purposes of this investigation, the entity of analysis is emergency petroleum supply chains. Dale Eikmeier's approach towards a COG analysis is used, which includes six steps: identify the entity's objective, identify the ways the entity will achieve the objective, determine the entity's means to accomplish the objective, determine entity's COG, assign critical requirements, and identify vulnerabilities (Eikmeier 2010, 158). These steps are the analytical procedures for determining the critical factors of emergency petroleum supply chains during Hurricane Sandy.

Step 1: Identify the organization's desired ends or objectives.

Identifying the system's objective is the first step of a COG analysis. The value of determining the objective first is that the system's COG is the "entity that possesses the

inherent capability to achieve the objective" (Eikmeier 2010, 152). By identifying the objective of emergency petroleum supply chains first, determining its COG during step four will be more precise. Discovering reoccurring themes and patterns through triangulation presents what the objective of emergency petroleum supply chains is.

Data Analysis

The NRF defines the term "response" as the actions associated with safeguarding lives, protecting property, mitigating adverse environmental effects, and stabilizing communities after incidents (DHS 2016, 1). The context for the term "response" relates to emergency petroleum supply chains since an emergency supply chain is an action that responds to an emergency (Shatzkin 2017, 13). This correlation between response and an emergency supply chain is a key pattern within an incident, which creates a "suddenness of occurrence of demand on a large scale, with very short lead times for a wide variety of materials" (Young and Peterson 2014, 173).

Dr. Ali Haghani and Abbas Afshar define the objectives for both commercial supply chains and emergency supply chains in their work *Supply Chain Management in Disaster Response.* They determine the essential difference between the two supply chains is demand-related. In commercial supply chains, "demand for products is comparatively stable and predictable," whereas in emergency supply chains, "demand occurs in irregular amounts and at irregular intervals and occur suddenly" (Haghani and Afshar 2009, 32). The theme of demand for emergency supply chains is that it occurs without warning and there is a high volume of required materials. This essential theme for emergency supply chains links back to Young and Peterson's understanding of emergency supply chain demand. After Hurricane Sandy, there was a high and sudden

demand for petroleum products due to a fuel shortage created by the incident (FEMA 2013, 1). The correlation between "response" and "demand" is a critical pattern for determining the objective of emergency petroleum supply chains.

Due to Hurricane Sandy's flooding and high winds, power outages were extensive across the Northeast resulting in refineries and terminals being closed or having reduced runs (DOE 2013, 14). As a result of Hurricane Sandys's effects, 7% of the nation's refining capacity was disrupted (NACS 2013, 64). With a limited ability to introduce petroleum products into the Northeast, refineries and terminals were unable to meet the daily requirement of "2.2 million barrels per day of gasoline and distillates (home heating oil and diesel fuel)" to the Northeast (NACS 2013, 64). Power outages also affected downstream of the petroleum distribution network, which includes gas stations. Roughly two-thirds of all gas stations within the New York metro area were without power and fuel during the aftermath of Hurricane Sandy (NACS 2013, 65). The two key aspects taken away from the fuel shortage were power and distribution. Power outages affected both upstream and downstream of the petroleum distribution networks. Refineries and terminals without power could not provide petroleum to the Northeast and gas stations downstream could not sell it, thus creating a sudden and large-scale demand for petroleum.

Analyzing the correlation between response and demand as a key pattern for emergency petroleum supply chains is ascertained. The objective of emergency petroleum supply chains is to "deliver petroleum to the point of need." Defining the objective of emergency petroleum supply chains is nested within one of the NRF's core capabilities of "Logistics and Supply Chain Management." The objective of the

"Logistics and Supply Chain Management" capability is to "deliver essential commodities, equipment, and services in support of impacted communities and survivors, to include emergency power and fuel support" (DHS 2016, 25). Response and demand are the key terms which create a pattern through triangulating data to determine the objective of emergency petroleum supply chains.

Step 2: Identify the possible "ways" or actions that can achieve the desired ends. Select the way(s) that the evidence suggests the organization is most likely to use.

With the objective of emergency petroleum supply chains determined, the next step of the COG analysis is to identify how emergency petroleum supply chains achieve their objective. The "ways" are the critical capabilities of emergency petroleum supply chains and are the "the primary abilities essential to the accomplishment of the objective" (JCS 2017, IV-25). "Ways" are depicted as verbs during the analysis of critical capabilities. Conducting this step determines what abilities emergency petroleum supply chains require. Additionally, this step reveals the critical capability of the COG within emergency petroleum supply chains. Determining the primary abilities is accomplished by triangulating data concerning the abilities of emergency petroleum supply chains.

Data Analysis

Distribution is the key critical capability of emergency petroleum supply chains as discovered through triangulating data from various sources. This determination was made by looking at commercial supply chains and emergency supply chains holistically and then focusing on the requirements of emergency petroleum supply chains during Hurricane Sandy. Furthermore, the analytical process of a COG analysis applies the definition of critical capabilities to help ascertain the way in which emergency petroleum

supply chains achieve their objective. For commercial supply chains, distribution is the action which delivers a finished product to consumers via transportation to meet a general demand (Waters 2003, 13). Distribution for emergency supply chains is the action of transporting resources to the point of care or need during a disaster (Ji and Zhu 2012, 315). During Hurricane Sandy, distribution was the key critical capability for emergency petroleum supply chains to provide 9.3 million gallons of fuel to New York and New Jersey (FEMA 2013, 6). Using the definition of critical capabilities as the way in which emergency petroleum supply chains achieve their objective, distribution is the critical capability of emergency petroleum supply chains.

Step 3: List the organization's means available or needed to execute the way/critical capability

Viewing emergency petroleum supply chains as an entity that executes the critical capability of distribution, the next step is to determine the means required of emergency petroleum supply chains. Means are critical requirements defined as the "essential conditions, resources, and means for a critical capability to be fully operative" (Eikmeier 2010, 158). The intent of step three is to list all available and essential critical requirements of emergency supply chains for the execution of emergency petroleum distribution.

List of Means

Emergency Declaration

The *Robert T. Stafford Disaster Relief and Emergency Assistance Act* grants the President special authorities to task Federal agencies to provide emergency assistance to state, local, and tribal governments (U.S. Congress 2016, 57). Additionally, an

Emergency Declaration provides the latitude for Federal agencies to support state and local governments with the "distribution of medicine, food, and other consumable supplies" such as petroleum (U.S. Congress 2016, 57). On October 30th, 2012, the President issued Emergency Declarations for New York and New Jersey, and subsequent Emergency Declarations for States affected by Hurricane Sandy (FEMA 2013, 5). Within the arch of these Emergency Declarations, the President also issued an executive order, to task the DOD's DLA-Energy to begin emergency petroleum distribution within the States of New York and New Jersey (Burke and McNeil 2015, 37). To support DLA-Energy's distribution of petroleum, the DOE transferred fuel from the Northeast Home Heating Oil Reserve to DLA-Energy. On three different occasions, the DOE transferred over five million gallons of fuel to DLA-Energy from the Northeast Home Heating Oil Reserve (DOE 2013, 29). As a critical requirement, emergency declarations and the subsequent executive orders issued by the President, set the conditions for the critical capability of distribution. By leveraging the authorities granted to the President through the *Stafford Act*, the President can direct Federal agencies, such as the DOD, to conduct emergency petroleum distribution. Without this essential critical requirement, distribution as a critical capability for emergency petroleum supply chains cannot be fully operative.

Waivers

On November 2, 2012, the *Merchant Marine Act of 1920*, known as the Jones Act, was waived. The Jones Act "prohibits foreign-built, foreign-owned, or foreign-flagged vessels from carrying goods between U.S. ports" to include petroleum and products to refine petroleum (DOE 2013, 25). The Jones Act waiver is also a critical requirement, which is another essential condition for the critical capability of distribution.

By waiving the Jones Act, foreign flagged ships were able to source 2.7 million barrels of petroleum into the distribution capability of emergency petroleum supply chains (DOE 2013, 30). The DHS coordinated with the DOD, DOE and the Maritime Administration for the Jones Act waiver, which was an essential condition for emergency petroleum distribution. Without the Jones Act waived, new sources of petroleum could not have been introduced into emergency petroleum supply chains, thus preventing the critical capability of distribution from being fully operative. The significance of the Jones Act waiver, as a critical requirement, was that local refiners and pipelines could not provide the required amount of petroleum to meet fuel demands of the Northeast.

Hubs

Petroleum distribution hubs are a critical requirement of emergency petroleum supply chains. The purpose of hubs is to enable the distribution of petroleum from the point of holding to the point of need (Baker, Croucher, and Rushton 2010, 226). Within the context of emergency petroleum supply chains, there are various types of hubs. A point of entry serves as the initial hub for the commodity of petroleum to enter emergency petroleum supply chains. A secondary hub is a central warehouse where the commodity of petroleum is linked with transportation assets to distribute petroleum to tertiary hubs. Tertiary hubs are known as local distribution centers that provide the commodity of petroleum to the point of need (Decker 2014, 14). During Hurricane Sandy, hubs that served as a point of entry where established due to the actions of the DOE and the DOD with the Jones Act Waiver and the fuel transfer from the Northeast Home Heating Oil Reserve. These petroleum points of entry were required since refiners within the affected area of Hurricane Sandy were operating with reduced capacities (DOE

2013, 14). Joint Base McGuire-Dix-Lakehurst was established as a secondary hub and identified as an intermediate staging base for transportation assets to distribute petroleum to tertiary hubs (Shawn 2013, 8). Tertiary hubs became existing gas stations and ad hoc locations to distribute petroleum to the point of need. For example, Foster Fuels, a private contractor, transported petroleum from Joint Base McGuire-Dix-Lakehurst to 272 different gas stations within the affected area (Foster Fuels 2013). As a critical requirement of emergency petroleum supply chains, hubs serve a vital role by providing a point of entry, secondary, and tertiary locations to facilitate the distribution petroleum.

Fuel Trucks

Fuel trucks are the entities which physically transport petroleum from supply hubs to the point of need (Baker 2010, 25). As a critical requirement of emergency petroleum supply chains, fuel trucks were essential towards making emergency petroleum distribution fully operative during Hurricane Sandy. DLA-Energy contracted approximately 300 fuel trucks through Fosters Fuels to distribute petroleum in both New York and New Jersey (Foster Fuels 2013). These fuel trucks primarily staged at Joint Base McGuire-Dix-Lakehurst and from that secondary hub conducted emergency petroleum distribution. To further support private contracting, the DOD tasked Title 10 forces to provide petroleum transportation as well. Employing the HEMTT fuel variant, active duty forces from the 10th Mountain Division distributed petroleum from 59 HEMTT fuel trucks, staged at Joint Base McGuire-Dix-Lakehurst (Stewart 2012). Both private sector and DOD fuel assets provided a critical requirement for emergency petroleum distribution by physically transporting petroleum to the point of need.

Petroleum

Petroleum products encompass a wide range of fuels to synthetic materials. In the context of this study, gasoline, diesel fuel, and home heating oil are the primary petroleum products of emergency petroleum supply chains. During 2012, the US consumed 4.7 million barrels of petroleum products a day. Of that 4.7 million barrels, the area affected by Hurricane Sandy required 2.2 million barrels of petroleum a day (NACS 2013, 64). Hurricane Sandy severely unsettled the nation's petroleum distribution industry by disrupting petroleum terminals, pipelines, and refineries, resulting in a massive fuel shortage (Gibbs and Holloway 2013, 21). As a result of the petroleum shortage caused by Hurricane Sandy, petroleum itself became the essential commodity to enable emergency petroleum distribution. Without the commodity of petroleum, as a critical requirement of emergency petroleum supply chains, the critical capability of distribution would have never occurred.

Planning and Management

Planning and management represent another critical requirement of emergency petroleum supply chains. The NRF provides both a planning cycle and a management structure to facilitate unified action amongst agencies during disaster response. During Hurricane Sandy, both planning and management systems were implemented by whole-of-government actors alongside the private sector to enable emergency petroleum distribution. Operational planning for emergency petroleum supply chains occurs due to the suddenness of a catastrophic event. To support operational planning, federal agencies conduct strategic planning to address incident response holistically before disasters occur. An example of strategic planning is USNORTHCOM's *CONPLAN 3501-08* which

addresses how the DOD will support DSCA operations and emergency petroleum distribution (USNORTHCOM 2008, 19-8). To conduct operational planning, the NRF outlines a six-step process which starts with forming a "collaborative team" to account for participating agencies. The second step is to assess the situation, which is conducted by the collaborative team. "Determining goals and objectives" is the third step of the planning process. Once goals are established, a plan is drafted by the collaborative team. With the plan completed, it is reviewed and approved by the collaborative team's senior leadership. The final step of the process is to monitor the plan, as it executes tasks to accomplish assigned objectives (DHS 2016, 48).

Operational planning for the employment of emergency petroleum supply chains shares similarities with Supply Chain Management practices. Distribution planning within the framework of Supply Chain Management follows the steps of assessing the situation through feedback, identifying objectives, planning, and monitoring the plan's progress (Baker 2010, 466). Both the Supply Chain Management planning process and FEMA's operational planning process highlight the importance of plans being objective oriented.

The NRF provides the ways in which agencies can respond to disasters by providing emergency petroleum distribution. Conducting emergency petroleum distribution is utilized by the NRF's core capability of "Logistics and Supply Chain Management." Operationalizing the core capability of "Logistics and Supply Chain Management" to manage emergency petroleum supply chains leverages the National Incident Management System (NIMS). NIMS provides the structure for how responding agencies can "manage resources," "conduct command and coordination," and "facilitate

communications and information management" (FEMA 2017, 2). During Hurricane Sandy, aspects of both the NRF and NIMS were applied by responding agencies to conduct emergency petroleum distribution.

With Hurricane Sandy approaching landfall, it triggered the activation of the National Response Coordination Center (NRCC) along with Regional Response Coordination Centers in Regions I, II, and III. The purpose of these coordination centers is to enable interoperability between the various ESFs. *ESF 12 Energy* has the role of coordinating the regeneration of energy systems by utilizing infrastructure systems, situational assessment, and the core capability of "Logistics and Supply Chain Management" (DHS 2016, 36). The DOE is responsible for coordinating *ESF 12 Energy* across all responding agencies to cultivate unified action. However, due to the sheer size and scope of the fuel shortage caused by Hurricane Sandy, the DOE was unable to effectively coordinate the energy response effort (FEMA 2013, 10). To regain the initiative, the DOE established the Energy Restoration Task Force from FEMA's NRCC (FEMA 2013, 28). Acting as a strategic level task force, the Energy Restoration Task Force provided guidance and direction to operational level management structures executing emergency petroleum distribution.

Management of emergency petroleum distribution at the operational level was managed from FEMA's Joint Field Office in Lincroft, New Jersey (OIG DHS 2015, 8). The role of a Joint Field Office is to provide a location where the private sector and all levels of government are integrated through ESFs to support response efforts (DHS 2016, 42). Operating at the Joint Field Office are State, Federal, and Defense Coordinating Officers who represent the equities of their respective agencies to facilitate integration

across the ESFs. Approximately 40 miles to the southwest of Lincroft was the Intermediate Staging Base of Joint Base McGuire-Dix-Lakehurst (JBMDL). JBMDL was used as a command post for the Joint Coordination Element to coordinate a multistate response amongst DOD Title 10 (Active) and Title 32 (National Guard) activities. From JBMDL, DLA-Energy and the Joint Coordination Element (JCE) coordinated with the FEMA Joint Field Office to felicitate the emergency distribution of petroleum. To generate a common operating picture, WebEOC was used to coordinate emergency petroleum distribution from the NRCC to an RRCC, then to the JFO and JCE (FEMA 2013, 11). WebEOC is "an online crisis management system" used to coordinate disaster response activities from the NRCC (FEMA 2013, 11). During Hurricane Sandy, these command posts at varying echelons of government managed emergency petroleum supply chains.

Step 4: Select the entity (noun) from the list of means that inherently possesses the critical capability to achieve the end. This selection is the center of gravity. It is the doer of the action that achieves the ends.

Step four of the analysis takes each of the means required of emergency petroleum distribution and applies them to a test. The objective of the "Doer and Used" test is to determine which of the items from the list of means has the inherent critical capability of distribution to achieve the objective of emergency petroleum supply chains. Determining which means possess the inherent critical capability of distribution is the COG of emergency petroleum supply chains. As the COG, it is the source of power for emergency petroleum supply chains, and where all efforts should be focused since the COG can achieve the entity's objective. Concerning the "Doer and Used" test in determining the COG for emergency supply chains, the following criteria apply.

Doer:

Only the center of gravity is inherently capable of achieving the purpose or objective.

If something executes the primary action(s) (capability) that achieves the objective, it is the COG.

The COG executes the action and used or consumes resources to accomplish it.

Used:

If something is used or consumed to execute the primary action (capability), it is a requirement.

If something contributes to, but does not actually perform, the action, it is a requirement, not a COG (Eikmeier 2010, 157).

From the list of means, the "Doer and Used" test criteria applies to each one to determine the COG of emergency petroleum supply chains. Each of the criteria asks a question to determine whether a mean is the doer or used by the doer. Since the "Doer and Used" test links to the entity's objective, the objective of emergency petroleum supply chains is "to deliver petroleum to the point of need." Furthermore, the test's criteria relates to the primary action which achieves the objective. The primary action is distribution and serves as the critical capability of emergency petroleum supply chains. By asking questions based on the criteria of the "Doer and Used" test, the mean which possess the doer attributes will be the COG of emergency petroleum supply chains.

<u>Emergency Declaration – Doer/Used Questions</u>

1. Does an emergency declaration inherently possess the capability of achieving the objective of emergency supply chains? No.
2. Does an emergency declaration execute the primary action that achieves the objective? No.

3. Is an emergency declaration used or consumed to execute the primary action? Yes.
4. Does an emergency declaration contribute to the primary action of achieving the objective? Yes.

Waiver – Doer/Used Questions

1. Does a waiver inherently possess the capability of achieving the objective of emergency supply chains? No.
2. Does a waiver execute the primary action that achieves the objective? No.
3. Is a waiver used or consumed to execute the primary action? Yes.
4. Do waivers contribute to the primary action of achieving the objective? Yes.

Hub – Doer/Used Questions

1. Does a hub inherently possess the capability of achieving the objective of emergency supply chains? No.
2. Does a hub execute the primary action that achieves the objective? No.
3. Is a hub used or consumed to execute the primary action? Yes.
4. Does a hub contribute to the primary action of achieving the objective? Yes.

Fuel Trucks – Doer/Used Questions

1. Do fuel trucks possess the capability of achieving the objective of emergency supply chains? Yes.
2. Do fuel trucks execute the primary action that achieves the objective? Yes.
3. Are fuel trucks used or consumed to execute the primary action? Yes.
4. Do fuel trucks contribute to the primary action of achieving the objective?

Yes.

Petroleum – Doer/Used Questions

1. Does petroleum possess the capability of achieving the objective of emergency supply chains? No.
2. Does petroleum execute the primary action that achieves the objective? No.
3. Are petroleum products used or consumed to execute the primary action? Yes.
4. Does petroleum contribute to the primary action of achieving the objective? Yes.

Planning and Management – Doer/Used Questions

1. Do planning and management possess the capability of achieving the objective of emergency supply chains? No.
2. Do planning and management execute the primary action that achieves the objective? No.
3. Are planning and management used or consumed to execute the primary action? Yes.
4. Do planning and management contribute to the primary action of achieving the objective? Yes.

The results of the "Doer and Used" test determines that fuel trucks are the COG for emergency petroleum supply chains. Fuel trucks meet the criteria of the doer, which is the entity that possesses the inherent ability to execute the primary action which accomplishes the objective. For emergency petroleum supply chains the primary action is distribution, and fuel trucks inherently possess this ability. All other means that are listed

support the distribution of petroleum. Secondly, by executing the primary action of distribution, only fuel trucks can achieve the objective of emergency petroleum supply chains. The remaining means do not possess the inherent capability to achieve the objective of emergency petroleum supply chains. “Having the inherent ability” is the key phrase in determining fuel trucks as the COG of emergency petroleum supply chains, since they can distribute fuel to the point of need.

Step 5: From the remaining items on the means list, select those that are critical for execution of the critical capability. These are the critical requirements.

Critical requirements are the “essential conditions, resources, and means for a critical capability to be fully operative” (Eikmeier 2010, 158). The results of the “Doer and Used” test determined that emergency declarations, waivers, hubs, petroleum, planning and management are all critical requirements since the critical capability of distribution requires them to be fully operative. Fuel trucks are a means which distribution requires, however since fuel trucks inherently possess the primary action of distribution that achieves the objective, they are not listed with critical requirements and identified as the COG. Emergency declarations, waivers, hubs, petroleum, planning and management all enable the critical capability of distribution. These are the critical requirements of emergency petroleum supply chains which possess the essential conditions, resources, and means of emergency petroleum distribution.

Step 6: Complete the process by identifying those critical requirements vulnerable to adversary actions.

The last step of the center of gravity analysis determines the critical vulnerabilities of critical requirements. Critical vulnerabilities are “those aspects or

components of critical requirements that are deficient, or vulnerable to direct or indirect attack in a manner achieving decisive or significant results" (JCS 2014, IV-12). The context of the "adversary" is Hurricane Sandy, which can make a critical requirement of emergency petroleum supply chains "deficient or vulnerable." As a catastrophic incident, Hurricane Sandy presents emergency petroleum supply chains with complex challenges which can degrade critical requirements. These challenges relate back to the variations found between commercial supply chains and emergency supply chains. Those challenges are the unpredictability of demand, the suddenness of the incident, human lives at risk, a pre-existing logistics infrastructure compromised, and lack of access to required resources (Young and Peterson 2014, 173). Of the critical requirements determined for emergency petroleum supply chains, the requirement for planning and management is most susceptible to being deficient or vulnerable due to the challenges presented by Hurricane Sandy. The vulnerabilities of planning and management are coordination and integration. The purpose of identifying critical vulnerabilities of critical requirements is to mitigate the effects of the adversary to achieve the desired objective. During the context of Hurricane Sandy, the COG analysis determined how the effects of the storm against the critical requirement of planning and management were mitigated.

The other critical requirements of emergency declarations, waivers, hubs, and petroleum, do not have critical vulnerabilities. As a physical adversary, Hurricane Sandy did not affect emergency declarations or waivers. Even though Hurricane Sandy was the cause for implementing emergency declarations and waivers to meet the demand for emergency petroleum distribution, it did not make these critical requirements deficient or vulnerable. Both emergency declarations and waivers are system mechanisms to facilitate

emergency petroleum supply chains and are isolated from the physical effects of Hurricane Sandy. Additionally, Hurricane Sandy was unable to make hubs and petroleum deficient or vulnerable. Locations for secondary and tertiary hubs to provide petroleum to the point of need were sufficient in quantity, despite the fact that Hurricane Sandy degraded the existing petroleum distribution network. As for petroleum, the Jones Act waiver and transferring fuel from the Northeast Home Heating Reserve provided new sources of petroleum to prevent this critical requirement from having a critical vulnerability. With Hurricane Sandy acting as the physical adversary, it was unable to affect the other critical requirements, and only affected the critical requirement of planning and management.

Due to the suddenness and unforeseen demand for fuel caused by the fuel shortage, Hurricane Sandy was able to degrade the capacity of planning and management for emergency petroleum supply chains. After Hurricane Sandy, it was discovered that both deliberate and incident planning suffered at various echelons of the National Response Framework, which includes the NRCC, RRCC, and JFOs (FEMA 2013, 15). Over 64% of FEMA planners that responded to Hurricane Sandy did not have access to or were not aware of pre-existing regional response plans (FEMA 2013, 15). Without the aid of pre-existing response plans, integration was not achieved across the NRCC, RRCCs, and the JFO. The suddenness and unforeseen demand for fuel magnified the vulnerabilities of planning and management as a critical requirement.

With emergency petroleum distribution plans developed through a disjointed process, the expanding demand for petroleum overwhelmed the DOE's efforts in coordinating *ESF 12 Energy*. Due to the increasing demand for petroleum and the scale

of the petroleum shortage, the President directed the DOE and FEMA to form an Energy Restoration Task Force to improve coordination efforts between local, state, and federal agencies (FEMA 2013, 10). The Energy Restoration Task Force was able to overcome the challenges of emergency petroleum distribution caused by Hurricane Sandy by integrating efforts amongst the DOD, Coast Guard, DOE, FEMA, Department of Transportation, and the private sector. The sudden and high demand for petroleum caused by Hurricane Sandy exposed the vulnerabilities of coordination and integration within the critical requirement of planning and management.

Results from the COG analysis determine the objective, critical factors, and the COG for emergency petroleum supply chains during Hurricane Sandy. The below diagram illustrates the results.

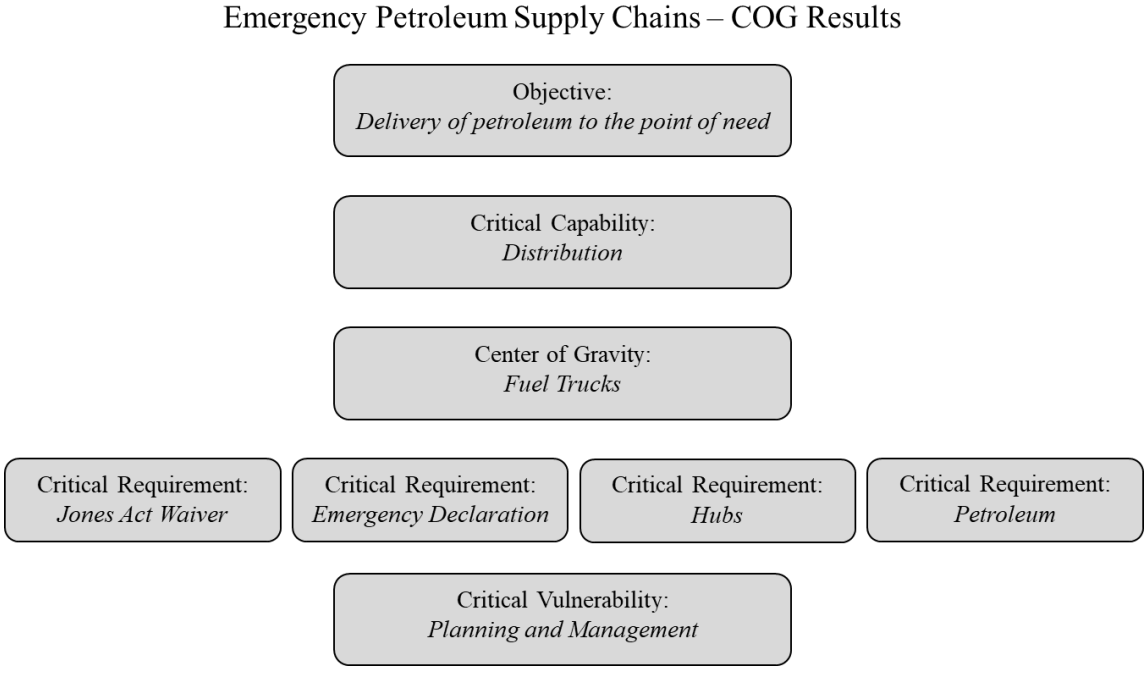

Figure 2. COG Results

Source: Created by author.

Summary

The purpose for investigating emergency petroleum supply chains through the COG concept is to determine how resources were committed against requirements to achieve objectives during Hurricane Sandy and to determine whether it is an applicable planning tool for future DSCA operations. As an analytical process, the COG concept first identifies the objective of emergency petroleum supply chains, which is to deliver petroleum to the point of need. The second step of the analysis determines the critical capability that provides the way to achieve the objective. For emergency petroleum supply chains, the critical capability is distribution. The third step determines the required means of emergency petroleum supply chains. The required means are emergency declarations, waivers, hubs, fuel trucks, petroleum, planning, and management. Step four assesses which of the means possesses the inherent ability of distribution. Fuel trucks are the means that possess the critical capability of distribution and are validated as the COG for emergency petroleum supply chains through the "Doer and Used" test. The fifth step determines the other means of the emergency petroleum supply chains as critical requirements and indicating that without them, the critical capability of distribution could never be fully operative. The final step analyzes potential vulnerabilities of the critical requirements to mitigate the adverse effects of Hurricane Sandy on emergency petroleum supply chains. The critical requirement of planning and management possesses

vulnerabilities brought on by the suddenness and high demand for petroleum by Hurricane Sandy.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Introduction

Results from the COG analysis render the importance and relevance of this study as it pertains to the first research question; "What are the critical factors of emergency petroleum supply chains?" Conclusions made by this study address the effect of emergency petroleum supply chains as they relate to the NRF and answer the second research question; "How effective was the *National Response Framework* in planning for and managing emergency petroleum supply chains?" Finally, the third research question of "How does this study advance the understanding of emergency supply chains?" addresses recommendations for further research.

Results

The complexity of emergency supply chains is brought on by their variations from commercial supply chains and their special characteristics which affect the efficiency and effectiveness of disaster response. This study investigates that complexity through the bounded case study of emergency petroleum supply chains during Hurricane Sandy. The goal of the investigation is to produce an alternative approach towards improving the effectiveness and efficiency of emergency supply chains by using the COG concept. Determining an entity's COG is an essential task for any Joint military staff, as the COG is the "source of power" that provides the "physical strength, freedom of action, or will to act" of an entity (JCS 2017, IV-23). To fully understand an entity and its source of power, it is vital to discover its critical factors. As an analytical tool, the COG concept

breaks down the complexity of emergency petroleum supply chains by determining it's critical factors.

The relevance of the study's results supports future application of emergency supply chains, and not just emergency petroleum supply chains. First, the COG analysis determines the objective of emergency petroleum supply chains, which is also a critical aspect of FEMA's six-step planning model for operational planning. Identifying the objective of emergency supply chains during disaster response is essential towards properly aligning ways and means to achieve the ends. As a planning element, the COG concept can assist FEMA's operational approach towards emergency supply chains through the core capability of "Logistics and Supply Chain Management." Secondly, the COG analysis discovered the critical vulnerability of planning and management. The critical vulnerability of planning and management is a relatable factor to other forms of emergency supply chains due to their complexity. With the critical vulnerability identified through the aid of the COG analysis, it's detrimental effects can be mitigated to improve the efficiency and effectiveness of future emergency supply chains. Thirdly, and most importantly, the analysis determines the actual COG of emergency petroleum supply chains. As the COG, fuel trucks are also a critical requirement which possesses the critical capability of distribution to achieve the objective of delivering fuel to the point of need. If used in future FEMA and DSCA operational planning, the COG concept can identify the COG of future emergency supply chains to improve their overall performance. Determining the COG of emergency supply chains can inform supporting agencies which critical requirements are essential in executing the primary way in which to achieve the objective, thus prioritizing requirements for disaster response. The

significance of the results provides an alternative approach towards deconstructing the complexity of emergency supply chains by analyzing the case study of emergency petroleum supply chains. This study provides a way towards an informed understanding of emergency supply chains by reducing their complexity through a COG approach.

Conclusions

The results of the analysis draw two conclusions from emergency petroleum supply chains stressing the NRF during Hurricane Sandy. First, emergency petroleum supply chains strained the *ESF 12 Energy* through the core capability of "Logistics and Supply Chain Management." Secondly, the suddenness and unforeseen petroleum requirements caused by Hurricane Sandy taxed *ESF 12 Energy*'s ability to coordinate emergency petroleum supply chains effectively. These conclusions are not only relatable for the future application of emergency petroleum supply chains but the larger continuum of emergency supply chains. Both conclusions correlate back to the effect of Hurricane Sandy on the NRF by overwhelming *ESF 12 Energy's* efforts to reduce petroleum supply disruptions.

As previously discussed, emergency supply chains contend with the abruptness and high demand for commodities within a degraded logistical environment, as seen with emergency petroleum supply chains during Hurricane Sandy. At the high water mark of the fuel shortage brought on by Hurricane Sandy, over 8.5 million residents of New York and New Jersey were affected (FEMA 2013, 10). The resulting high demand for petroleum overwhelmed the Department of Energy's ability to effectivity coordinate *ESF 12 Energy* across local, state, and federal agencies to address the fuel shortage (FEMA 2013, 10). As the lead coordinator of *ESF 12 Energy*, the DOE did not have the inherent

capacity to plan for or manage a fuel shortage of that scale. As a result of this effect, it stressed the NRF in meeting the demands of the fuel shortage. However, the principles of "unity of effort through unified command" and "engaged partnership" provided by the NRF, gave *ESF 12 Energy* the pliability to bounce back by establishing the Energy Restoration Task Force (DHS 2016, 5). As a unified effort, the Energy Restoration Task Force was able to mitigate *ESF 12 Energy's* reduced capacity in planning and managing emergency petroleum supply chains. The massive onset of a fuel shortage and a lack of capacity in planning and managing provides the "how" and "why" emergency petroleum supply chains initially stressed the NRF.

An investigation of emergency petroleum supply chains through a COG approach leads to these conclusions. While a significant advantage exists when assessing emergency petroleum supply chains in a historical context, and not during the actual execution of them, the COG concept remains a powerful tool for analysis and planning. The analysis of emergency petroleum supply chains determined the critical vulnerability of emergency petroleum supply chains as planning and management. This vulnerability led to the ineffectiveness of emergency petroleum supply chains until the Energy Restoration Task Force galvanized planning and management. In mitigating this critical vulnerability, the COG of emergency petroleum supply chains, identified as fuel trucks, was fully empowered to execute the primary action of distribution to achieve the objective of delivering fuel to the point of need. However, the complexity of emergency supply chains is an enduring issue, due to their variations from commercial supply chains. Despite this complexity, the use of the COG concept to determine the critical factors of emergency supply chains can aid in reducing their complexity in future

applications. Most apparent is the critical vulnerability of planning and management, discovered by the COG analysis. A way to improve the effectiveness and efficiency of future emergency supply chains is to mitigate the weaknesses of planning and management, rather than forming ad hoc organizations such as the Energy Restoration Task Force. Determining and mitigating this vulnerability, or other unforeseen vulnerabilities, can be achieved through a COG analysis for future emergency supply chains.

Recommendations for Further Research

This study explored the complexity of emergency supply chains through the bounded case study of emergency petroleum supply chains during Hurricane Sandy. Investigating emergency petroleum supply chains applied the COG concept to ascertain the critical factors as an alternative approach towards reducing the complexity of emergency supply chains. As an accepted element of operational design for Joint planning within the DOD, the COG concept proved to be an effective tool for analyzing emergency supply chains. Additionally, the COG concept is used by the DOD as a planning element and is one of the most important aspects of operational design. Therefore, a recommendation for further research is to explore whether FEMA should incorporate the COG concept into its existing six-step planning methodology for operational planning. The applicability of this recommendation would assist FEMA and federal agencies in determining the critical factors of future emergency supply chains. As a planning tool that can reduce the complexity of emergency supply chains, the COG concept determines critical factors which are objective-oriented. Critical factors include critical vulnerabilities which can reduce the effectiveness and efficiency of emergency

supply chains, as seen with planning and management during Hurricane Sandy. This recommendation sustains the overall goal of reducing the complexity of emergency supply chains.

Summary

The challenges of emergency supply chains are their variations from commercial supply chains and special characteristics that can stress the NRF. The importance of effective and efficient commodity distribution during disaster response was most apparent during the fuel shortage caused by Hurricane Sandy. To reduce the complexity of emergency petroleum supply chains this study applies the COG concept as an analytical tool. By doing so, the analysis discovered the critical factors of emergency petroleum supply chains, their effect on the NFR, and how the COG concept may be applicable for future use to address the research questions. The results of the analysis determined the key critical vulnerability of planning and management which initially affected the effectiveness of emergency petroleum supply chains. This effect stressed the capacity of *ESF12 Energy,* and was unable to meet the demands of the fuel shortage. As a planning tool, this study proposes incorporating the COG concept into FEMA's existing operational planning methodology. The significance of the COG concept will identify critical factors early on to mitigate potential critical vulnerabilities of future emergency supply chains. Ways to incorporate the COG concept into FEMA planning is a recommendation for future research. Finally, the purpose of this study is to contribute to the discussion regarding the complexity of emergency supply chains by investigating the bounded case study of emergency petroleum supply chains. The results of the investigation demonstrate how to apply the COG concept towards future planning efforts

by determining the critical factors of emergency supply chains. As an alternative approach towards understanding the complexity of emergency supply chains, this study hopes that the COG concept, which is already being practiced by the DOD, is seen as a viable planning element amongst federal agencies.

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