AMERICA'S ACHILLES HEEL: DEFENSE AGAINST HIGH-ALTITUDE ELECTROMAGNETIC PULSE–POLICY VS. PRACTICE

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This thesis examines the strategic level policies and practices of Electromagnetic Pulse (EMP) consequence management and how they translate down to the lowest echelon in the practices in addressing the potential second and third order effects. With the proliferation of nuclear devices and ballistic missile delivery systems, an EMP attack originating from a rogue or non-state actor is a potentially catastrophic threat that needs to be addressed. EMP has the potential to irrevocably damage electronics and electrical components over an extensive geographical area with some estimates of a grid outage lasting as long as 18 months. This is in part due to the current design limitations and vulnerabilities inherent in an aging infrastructure. Case study data from high altitude nuclear testing from the 1960s and EMP simulations are used to highlight the effects of EMP. The Defense Support of Civil Authorities (DSCA) mission of the military will be needed to bolster Department of Homeland Security efforts in a regionally widespread disaster area. Policies and legislation to address U.S. electrical grid vulnerabilities can take several years between milestones. Recommendations will address both governmental and private sector approaches to EMP damage mitigation and consequence management.

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ABSTRACT

AMERICA’S ACHILLES HEEL: DEFENSE AGAINST HIGH-ALTITUDE ELECTROMAGNETIC PULSE–POLICY VS. PRACTICE, by Major Sirius T. Bontea, 101 pages.

This thesis examines the strategic level policies and practices of Electromagnetic Pulse (EMP) consequence management and how they translate down to the lowest echelon in the practices in addressing the potential second and third order effects. With the proliferation of nuclear devices and ballistic missile delivery systems, an EMP attack originating from a rogue or non-state actor is a potentially catastrophic threat that needs to be addressed. EMP has the potential to irrevocably damage electronics and electrical components over an extensive geographical area with some estimates of a grid outage lasting as long as 18 months. This is in part due to the current design limitations and vulnerabilities inherent in an aging infrastructure. Case study data from high altitude nuclear testing from the 1960s and EMP simulations are used to highlight the effects of EMP. The Defense Support of Civil Authorities (DSCA) mission of the military will be needed to bolster Department of Homeland Security efforts in a regionally widespread disaster area. Policies and legislation to address U.S. electrical grid vulnerabilities can take several years between milestones. Recommendations will address both governmental and private sector approaches to EMP damage mitigation and consequence management.

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This is study is dedicated to the men and women within the military ranks and the civilians in the government and the private sector who work tirelessly behind the scenes to safeguard our nation and preserve the American way of life as outlined within the framework of the U.S. Constitution. I would like to express my sincere gratitude to all the men and women that served in the military since the Revolutionary War. Without the valiant efforts and sacrifices of the patriots that came before us, the current generation of Soldiers, Airmen, Sailor, and Marines would not exist today.

I would like give to special thanks my committee, Mr. Loye W. Gau, Dr. Shawn Cupp, and Mr. Britt W. Estes for their depth of knowledge, expertise, dedication, and guidance on this research project. Throughout my time at the Command and General Staff College, you gave me the tools and valuable insight to help me to understand and critically think about the world around me. You guys are truly great Americans.

Most importantly, I want to thank God for blessing me with my wonderful wife, Laura, and my daughter, Lily. To my wife and daughter, thank you both for your love and understanding when I had to put in those extra hours of research and writing after hours. You two gave me the motivation to work hard and not give up. You two give me the inner strength to go the extra mile and to keep fighting the good fight. As President Ronald Reagan eloquently stated, “Freedom is never more than one generation away from extinction. We did not pass it to our children in the bloodstream. It must be fought for, protected, and handed on for them to do the same.”

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ACRONYMS

CBRN	Chemical, Biological, Radiological, and Nuclear
CBRN CM	Chemical, Biological, Radiological, and Nuclear Consequence Management
CI/KR	Critical Infrastructure and Key Resources
CIPA	Critical Infrastructure Protection Act
CME	Coronal Mass Ejection
DHS	Department of Homeland Security
DOD	Department of Defense
DPRK	Democratic People’s Republic of Korea
DSCA	Defense Support of Civil Authorities
EMP	Electromagnetic Pulse
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FM	Field Manual
GRID Act	Grid Reliability and Infrastructure Defense Act
HEMP	High-Altitude Electromagnetic Pulse
JP	Joint Publication
MISO	Midwest Independent System Operator
NERC	North American Electrical Reliability Corporation
NIMS	National Incident Management System
NIPP	National Infrastructure Protection Plan
NISAC	National Infrastructure Simulation and Analysis Center

NMS	National Military Strategy
NORAD	North American Aerospace Defense Command
NSS	National Security Strategy
POTUS	President of the United States
PPD	Presidential Policy Directives
SCADA	Supervisory Control and Data Acquisition Systems
SHIELD Act	Secure High-voltage Infrastructure for Electricity from Lethal Damage Act
U.S.	United States

ILLUSTRATIONS

CHAPTER 1

INTRODUCTION

> Nuclear warfare is not necessary to cause a breakdown of our society. You take a large city like Los Angeles, New York, Chicago—their water supply comes from hundreds of miles away and any interruption of that, or food, or power for any period of time you're going to have riots in the streets. Our society is so fragile, so dependent on the interworking of things to provide us with goods and services, that you don't need nuclear warfare to fragment us anymore than the Romans needed it to cause their eventual downfall.[1]
>
> — Gene Roddenberry

Background

It has been a hectic week and Jim Bob is looking forward to getting home to spend the weekend with his daughters. He patiently endures the 5 o'clock Los Angeles traffic as he makes his way to Big Bear, roughly 95 miles inland. The economy has been hard on everyone and Jim Bob, like many blue-collar Americans, has had to take jobs that resulted in long commutes. He does this journey five days a week along Highway 210, nearly two hours each way. Jim Bob has always had a good attitude, despite his circumstances, he is happy to have a decent paying job that can adequately provide for his family. He smiles to himself as he pictures his daughters rushing to the door to give him a big hug when he arrives home.

It is mid-July and the temperatures are just over 100 degrees Fahrenheit. Jim Bob goes turns up the air conditioning nob on his dashboard to compensate for the hot summer temperatures. All of a sudden, he notices the check engine light flicker

[1] James Wesley Rawles, *Patriots: Surviving the Coming Collapse*, 4th ed. (Berkeley, CA: Ulysses Press), 1.

momentarily and his truck engine stops running. He tries to restart the engine, to no avail. He coasts to the shoulder of the road when he notices other cars are trying to do the same thing. Jim Bob pulls out his cellphone to call his wife when he notices that his phone is also dead. In less than a minute, the highway has turned into a parking lot as far as he can see.

The cause of the scenario depicted above is not an isolated event, but has impacted millions of people in the State of California. Electronics and electrical systems are damaged due to the effects of an Electromagnetic Pulse (EMP) across a large geographical area. A commercial cargo ship located in international waters 200 hundred miles off the coast of San Francisco was part of a coordinated effort and elaborate plan between Islamic extremists and North Korea to launch a nuclear missile straight up into the Earth's upper atmosphere and detonated at an altitude of 250 miles. The timing of the launch was specifically chosen to maximize blockage of national highways with stalled vehicles and thus severely limit the freedom of movement of crisis response teams and rescue workers, especially in urban areas. Fortunately, this scenario is only a hypothetical thought exercise.

What exactly is an EMP? Though the term is defined as the "electromagnetic radiation from a strong electronic pulse, most commonly caused by a nuclear explosion that may couple with electrical or electronic systems to produce damaging current and voltage surges."[2] This textbook definition alone does not adequately explain what an EMP really is. Additionally, lightning strikes are often described as being a source of

[2] Chairman of the Joint Chiefs of Staff, Joint Publication 1-02, *Department of Defense Dictionary of Military and Associated Terms* (Washington, DC: Government Printing Office, 2014), 82.

EMP.[3] While this is technically true, it does not provide sufficient detail to understand the effects and characteristics EMP specifically emanates from a nuclear explosion. There are important differences in the EMP characteristics based on the specific source, be it from nuclear, lightning, or from coronal mass ejection (CME).

Within the context of an EMP originating from a nuclear explosion, there are three distinct pulse components each with their own unique characteristics. The first component is referred as the E1 pulse, which occurs extremely rapidly following a nuclear explosion.[4] The effect of the E1 pulse component is that it can induce very high voltage spikes that overwhelm most surge protectors by causing this voltage to spike faster than standard surge protectors can protect against.[5] Though there are surge protectors available that are quick enough to respond to the E1 pulse component, they are rarely used within civilian infrastructure.[6]

What is somewhat counterintuitive in studying High-Altitude Electromagnetic Pulse (HEMP) is that there is no reduction in effects due to distance.[7] On the surface, HEMP seemingly does not follow the inverse-square law in that intensity is inversely

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[3] Edward Savage et al., "The Early-Time (E1) High-Altitude Electromagnetic Pulse (HEMP) and Its Impact on the U.S. Power Grid," Metatech Corporation, January 2010, 2-6, 2-7, accessed October 26, 2014, http://www.ornl.gov/sci/ees/etsd/pes/pubs/ferc_Meta-R-320.pdf.

[4] Jerry Emanuelson, "An Introduction to Nuclear Electromagnetic Pulse," Futurescience, LLC, accessed September 1, 2014, http://www.futurescience.com/emp.html.

[5] Ibid.

[6] Ibid.

[7] Ibid.

proportional to the square of the distance from the source.[8] Why does HEMP originating from a nuclear explosion from hundreds of miles above the Earth's surface increase in overall intensity the further away it originates? No physical laws are violated in the E1 pulse's intense gamma burst as it does follow the inverse-square law.[9] However, what occurs in this burst of gamma radiation is an interaction with the upper atmosphere and Earth's magnetic field that ultimately causes electrons to be forced in a generally downward direction towards the surface at nearly the speed of light.[10]

Essentially, the E1 pulse causes the upper and middle portions of the atmosphere to become the source region for high-speed electrons, which in turn can interact with and damage electrical and electronic components over a large geographical area.[11] The span of this geographical area is the line of sight of the original HEMP source, even if it is over a thousand miles above the surface.[12] The induced source region, the middle atmosphere in this case, is the source of high-speed electrons themselves that is only few kilometers overhead.[13] Figure 1 illustrates to the effects of the E1 pulse component of HEMP and the affected geographical area, where HOB is the height of the nuclear burst in kilometers.

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[8] Wikipedia, "Inverse-Square Law," last modified June 20, 2014, accessed September 14, 2014, http://en.wikipedia.org/wiki/Inverse-square_law.

[9] Jerry Emanuelson, "E1, E2 and E3," Futurescience, LLC, accessed September 1, 2014, http://www.futurescience.com/E1-E2-E3.html.

[10] Ibid.

[11] Emanuelson, "An Introduction to Nuclear Electromagnetic Pulse."

[12] Ibid.

[13] Ibid.

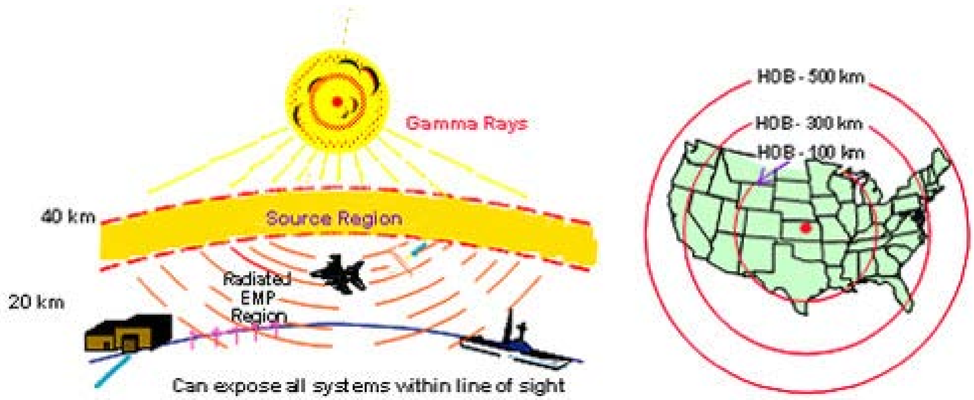

Figure 1. High-Altitude Electromagnetic Pulse (HEMP), E1 Effects

Source: Jerry Emanuelson, "An Introduction to Nuclear Electromagnetic Pulse," Futurescience, LLC, accessed September 1, 2014, http://www.futurescience.com/emp.html.

The second EMP component is the E2 pulse, which is very similar to the characteristics in terms of strength and timing to those produced by lightning strikes.[14] As such, the E2 component is thoroughly documented and the easiest to protect against. This is also the component least likely to cause widespread damage because most electrical systems have protective measures built into their designs.[15] However, since the E2 component immediately follows the E1 pulse, systems damaged by the initial E1 pulse are at greater risk to additional damage by the E2 pulse component.[16]

The third component is the E3 pulse, which has very different characteristics than the E1 and E2 pulse components. The E3 pulse is a much slower pulse in that can last tens to hundreds of seconds. The E3 pulse component is caused by the severe distortion

[14] Emanuelson, "E1, E2 and E3."

[15] Ibid.

[16] Ibid.

of the Earth's magnetosphere by the blast of the nuclear explosion.[17] The blast forces the Earth's magnetic field out its way and is followed by the subsequent restoration of the magnetic field to its original state.[18] This can be visualized by imagining the effect of a stone being dropped into a calm pond. Initially, an area of displaced water at the point of impact is formed by the pressure wave caused by the stone, followed by the immediate return of water to fill the void. The E3 component is very similar to the effects of a geomagnetic storm caused by CME interaction with the Earth's upper atmosphere.[19]

In order to understand what damage mitigation efforts need to take place, it is important to understand the effects of the components of EMP from a high-altitude nuclear detonation. The requirements for shielding equipment are inherently different depending on the EMP source.[20] Since HEMP has the E1, E2, and E3 pulse components, the potential for damage or destroyed electrical and electronic equipment is significantly greater.[21] Damage to equipment is more than just an inconvenience. HEMP has the potential to cause widespread damage to the infrastructure that is fundamentally important to everyday aspects of our lives.[22] Figure 2 highlights some examples of how these various infrastructures are interconnected.

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[17] Ibid.

[18] Emanuelson, "E1, E2 and E3."

[19] Emanuelson, "An Introduction to Nuclear Electromagnetic Pulse."

[20] Ibid.

[21] Emanuelson, "E1, E2 and E3."

[22] Emanuelson, "An Introduction to Nuclear Electromagnetic Pulse."

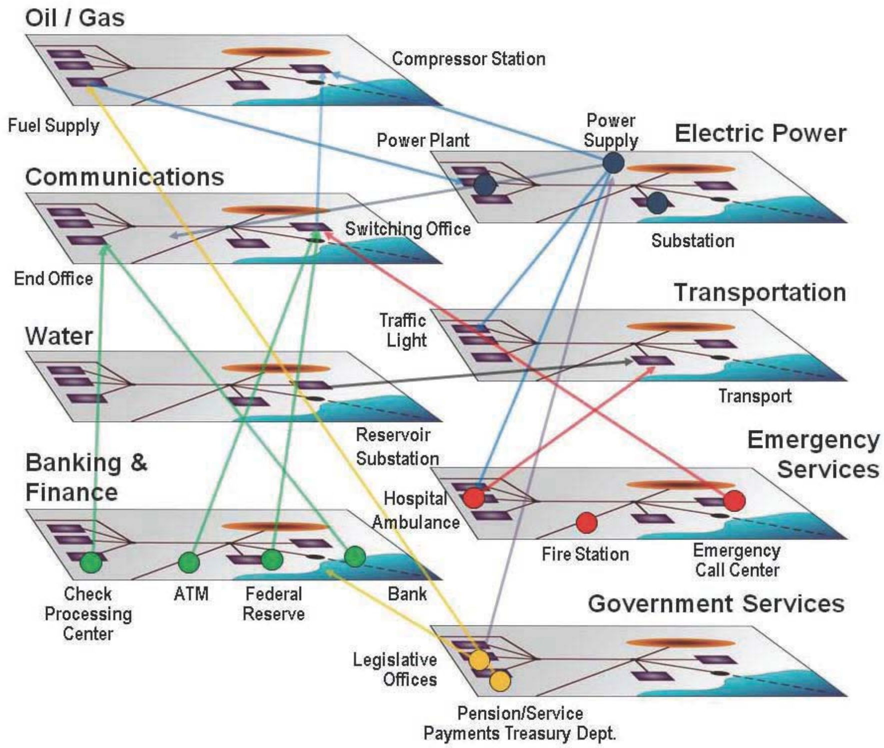

Figure 2. Depiction of Interconnected Infrastructures

Source: Dr. John S. Foster, Jr. et al., *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Critical National Infrastructures* (McLean, VA: Electromagnetic Pulse (EMP) Commission, 2008), 12.

The Critical Infrastructures and Key Resources (CI/KR), defined as "the infrastructure and assets vital to a nation's security, governance, public safety, economy, and public confidence,"[23] are an immensely interconnected and interdependent system of systems. Figure 2 illustrates that within this system of systems, electrical power is a

[23] Chairman of the Joint Chiefs of Staff, Joint Publication 3-27, *Homeland Defense* (Washington, DC: Government Printing Office, 2013), 141.

system that has primacy over all other systems.[24] Though it can be argued that water is more critical to actual human needs than electricity, water infrastructure in the U.S. is dependent on electrical power to pump and provide the necessary pressure to transport water across the vast network of pipelines throughout the country. The requirement for electrical power to supply water is greatly increased in cities, as there is much greater water consumption and a need to provide sufficient pressure to supply multi-story buildings.

To put energy consumption and water supply into context, the U.S. Environmental Protection Agency (EPA) breaks down the process of supplying water into five steps in which electricity is a requirement of all: extracting and conveying water, treating water, distributing water, using water, collecting and treating wastewater.[25] Extracting and conveying water is also a multistage process within the overall process. Water extracted from streams, rivers, lakes and reservoirs or pumped from aquifers is then conveyed over various elevations and distances are inherently energy intensive.[26] For example, California's State Water Project is the state's largest single user of electricity with an average consumption of 5 billion kilowatt-hours per year, or roughly 2

[24] Dr. John S. Foster, Jr. et al., *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Critical National Infrastructures* (McLean, VA: Electromagnetic Pulse (EMP) Commission, 2008), 12.

[25] U.S. Environmental Protection Agency, "Water-Energy Connection," July 17, 2014, accessed July 31, 2014, http://www.epa.gov/region9/waterinfrastructure/waterenergy.html.

[26] Ibid.

to 3 percent of all the power used in the State of California. This is partially due to having to pump over an elevation of 2,000 feet over the Tehachapi Mountains.[27]

Once extracted and conveyed, water is then treated. This treatment requires energy to pump and process in order to render it safe for consumers.[28] Once this water is distributed, additional energy is used by end users to treat, soften, heat and cool, and circulate and pressurize water for use in various functions such as home and agricultural use.[29] The increased consumption of energy at all of these stages consumes significant resources. Additionally, the final stage of this cycle is the treatment of wastewater. This process is also energy intensive, as water needs to be pumped, aerated, and filtered at a treatment plant.[30] The five stages within the energy and water process are repeated across the country to varying degrees. The water supply at a national level depends heavily on electrical power as a fundamental requirement, and thus demonstrates the interconnected and interdependent nature of these two pieces of critical infrastructure.

To put these figures into context for energy measurement and consumption, 1 kilowatt-hour is the amount of energy required to light one 100-watt light bulb for 10 hours.[31] This means that the 5 billion kilowatt-hours used by California's State Water

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[27] Ibid.

[28] Ibid.

[29] Ibid.

[30] Ibid.

[31] Martin Ramsey, "How much does it cost to use a 100 watt bulb for 1 hour," Energy Advisory Service UK, September 23, 2011, accessed September 23, 2014, http://energy-advise.com/2011/09/23/how-much-does-it-cost-to-use-a-100-watt-bulb-for-1-hour/.

Project is equivalent to the power needed to keep approximately 2 billion light bulbs lit for one day.[32] Though 2 to 3 percent may seem insignificant, it is important to note that California is an energy deficient state. For California in particular, this means that it has it to import 30% of the electricity it needs from its neighbors due to its inability to generate enough of its own power.[33] As a result, a power grid disruption in a state that exports electricity to California could potentially leave the state vulnerable to grid failure due to energy requirements exceeding the state's available energy and capacity to compensate.

To further highlight that electricity is the prime component of the CI/KR system of systems, any disruption to electrical power for any significant length of time puts other systems at risk of failure. Many industries have a requirement for continuous and uninterrupted electrical power. A prime example would be aluminum factories, as they require enormous amounts of electricity to process bauxite, the most common form of aluminum ore, into useable aluminum metal.[34] Additionally, aluminum factories need electricity to maintain aluminum heated to a liquid state as the primary means to quickly transport the material through a large array of channels and molds for further processing.[35] Aluminum factories, and other industries with similar power requirements,

[32] Ibid.

[33] The California Energy Almanac, "California Electricity Statistics and Data," accessed September 13, 2014, http://energyalmanac.ca.gov/electricity/.

[34] William Harris, "How Aluminum Works," HowStuffWorks.com, September 29, 2008, accessed May 28, 2013, http://science.howstuffworks.com/aluminum.htm.

[35] Ibid.

are generally located near hydroelectric power plants and other sources of relatively inexpensive energy.[36]

In the event that electricity is disrupted, molten aluminum in a factory would solidify and render the factory useless. Repairs would likely require electricity for drilling and other time consuming means to restore the equipment back to their operational states. Industries that have these types of power and operating requirements generally have back-up power generators onsite to provide a temporary measure against loss of power until primary grid power can be restored. Most industries have emergency generators that are limited in their capacity in that they can only provide power for up to 72 hours.[37] This is due to fire safety and pollution concerns for locally stored fuel in populated areas.[38]

Additionally, the ripple effect of this particular example on other industries that require aluminum products will be compounded by the problems associated with the potential for job losses in interrelated industries. Backup power generation at these types of factories can be used to keep equipment running and prevent damage. In the event of an extended power outage, these back up systems can be used to allow sufficient time for these industries to safely bring their equipment offline. However, an EMP would likely damage the backup generators and computer systems that allow for these systems to come online and prevent the necessary safety measures to be conducted. This could undoubtedly result in costly repairs and the possibility of irrevocable damage to equipment.

[36]Ibid.

[37] Foster et al., *Commission to Assess Threat from EMP*, 19.

[38] Ibid.

The water distribution infrastructure is something that most people take for granted. We turn on the faucets, take showers, and flush toilets each and every day with no thought about the vast network of pipelines, reservoirs, and machinery used to keep this whole system running. The infrastructure that keeps the water flowing behind the scenes is powered in part by gravity, but mostly through electrical power. The various types of electrical systems such as pumps, valves, filters, and machinery used for purification and wastewater management are especially vulnerable to EMP.[39] Damaged or destroyed components from an EMP attack on these systems can disrupt the whole water distribution system and result in the introduction of wastewater pollutants such as chemicals and pathogens.[40]

Other heavily energy dependent industries, such as petroleum and natural gas industries, are often overlooked in our daily lives. We pump gas into our vehicles and cook with propane without much thought into the vastness of the infrastructure needed to provide these essential services. The primary physical component of this infrastructure lies in its extensive pipeline transportation network. Crude oil moves from the fields onward to the refineries for processing and finally for distribution of the finished product to the end user.[41] Across the U.S., there are upwards of 40,000 miles of gathering lines from the oil wells, both on and offshore, that feed into 55,000 miles of trunk lines that transport the crude oil to regional refining facilities. Additionally, there are another 95,000 miles of pipeline that move the refined products, such as gasoline, diesel, and jet

[39] Ibid., 142.

[40] Ibid.

[41] Ibid., 95-96.

fuel, that augment the transportation conducted by tankers.[42] Finally, their natural gas component has its own array of pipelines that consist of 300,000 miles of interstate and intrastate lines and over 1.8 million miles of distribution lines that bring natural gas to individual homes and businesses.[43] Figure 3 depicts a rough schematic of the petroleum and natural gas infrastructure.

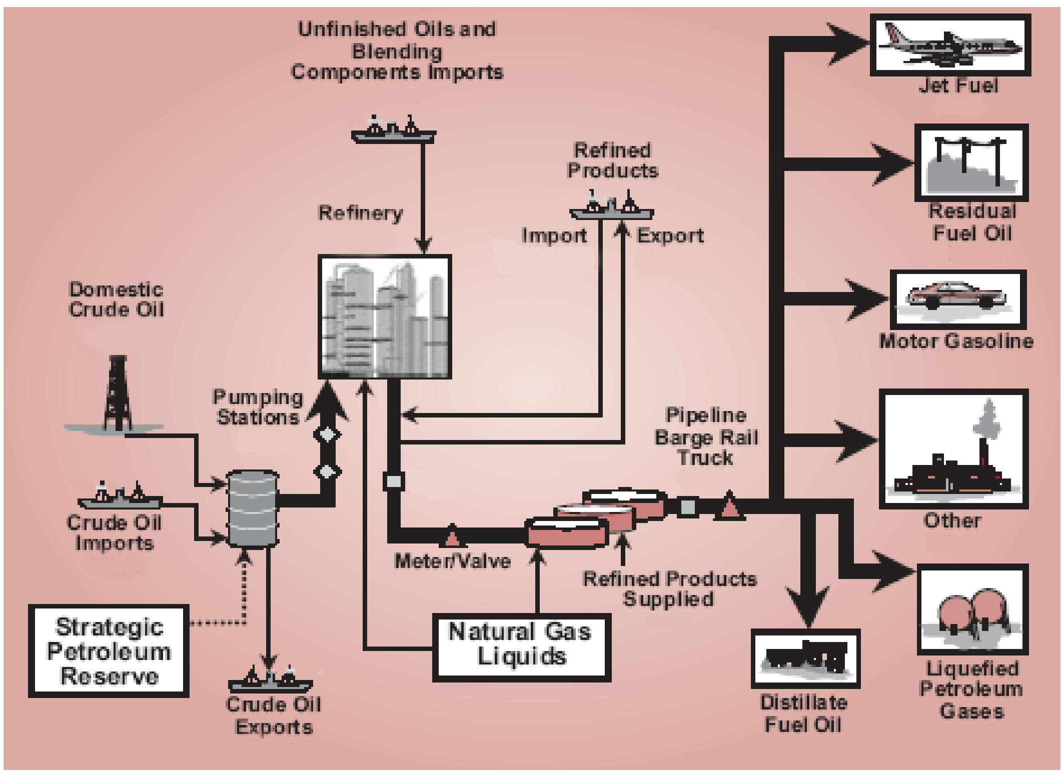

Figure 3. Petroleum and Natural Gas Infrastructure

Source: Dr. John S. Foster, Jr. et al., *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Critical National Infrastructures* (McLean, VA: Electromagnetic Pulse (EMP) Commission, 2008), 96.

[42] Ibid., 96.

[43] Ibid., 97.

The infrastructure of both petroleum and natural gas requires continuous power to run the all the electrical subcomponents within the system. Pumps are used for extraction of the crude fuels from wells and for transportation within the array of pipelines. Electrical systems and computers monitor and manage the flow of these materials from wells, through all the intermediate stages, all the way to the consumer.[44] Supervisory Control and Data Acquisition Systems (SCADA) is the subcomponent that is most vulnerable within this network.[45] SCADAs are located over the whole geographical layout of the pipeline network and are distributed across all of the different infrastructure elements. SCADAs ensure efficiency of this system by regulating the flow of material and ensure that strict safety measures are enforced to prevent injuries or fatalities.[46] The operation of the other mechanical systems with the transportation infrastructure is also controlled by SCADAs. The potential impact of EMP on SCADA would severely compromise or in some cases, prevent the transportation infrastructure from functioning altogether.[47]

Besides water infrastructure and the petroleum and natural gas industries, countless other systems require electricity. Computer systems in general, from data centers to air traffic control systems, to telecommunications and the Internet, all require electrical power in order to function.[48] Some independent computer systems, such as

[44] Ibid., 96.

[45] Ibid., 98.

[46] Ibid.

[47] Ibid.

[48] Ibid., 62.

those found in aircraft and automobiles, do not require power from the grid. However, these independent computer systems are still susceptible to the effects of EMP. The surge of electromagnetic radiation from EMP, though harmless to humans, can still cause significant damage to electrical systems and electronics by way of a spike in voltage.[49]

Electronics are especially vulnerable to EMP because a spike in voltage will literally burn and render these components useless, regardless of whether or not they are connected to the electrical grid.[50] The key point is that EMP can cause widespread damage to electrical systems and can ultimately disrupt electrical power for extended periods of time due to the need to repair or replace damaged parts.[51] EMP and HEMP will be discussed in more detail in chapter 2.

The Research Question

Data from numerous experiments show that Electromagnetic Pulse (EMP) could potentially cripple Critical Infrastructure and Key Resources (CI/KR) leading to extensive disruption to electrical power, communications, and travel. The primary purpose of this study is to evaluate U.S. national policies and practices and how they coincide with a level of response needed to manage the immediate consequences of an EMP attack. Secondary questions relate to the broader aspect of consequence management. Are the current policies and practices sufficient to mitigate secondary and tertiary effects of widespread power disruption? What level of law enforcement would be

[49] Emanuelson, "An Introduction to Nuclear Electromagnetic Pulse."

[50] Ibid.

[51] Ibid.

required to mitigate the potential for widespread civil unrest in the event of widespread power disruption for a prolonged period of time? It is important to note that the term "practices" in this case refers not merely to the actions and procedures conducted by a particular agency or individual, but also includes the additional resourcing of equipment and adequate funding.

Assumptions

The idea behind a nuclear attack against the United States of America is nothing new. U.S. military strategists have had to contend with the possibility of nuclear strikes against the homeland since the dawn of the Cold War. After the Soviets detonated their first atomic weapon in 1949, the American people were well aware of the possibility of nuclear strikes from the Soviet Union. Nuclear fallout shelters were clearly marked and evacuation drills were conducted with regularity in the 1950s and 60s.[52] Additionally, it was not uncommon to see simple underground "bunker kits" containing canned food and water filtration devices being advertised in magazines and periodicals as late as the 1980s. These advertisements, particularly for the smaller kits, were purposefully directed towards the average American's fear of the ever-present threat of nuclear war. This was also part of a much larger $30 billion national level effort to construct fallout shelters across the country in response to the Soviet nuclear threat.[53]

[52] The History Channel, "Gaither Report calls for more U.S. missiles and fallout shelters," accessed September 14, 2014, http://www.history.com/this-day-in-history/gaither-report-calls-for-more-us-missiles-and-fallout-shelters.

[53] Ibid.

With the dissolution of the Soviet Union, the threat of nuclear war appears to have greatly diminished, at least for the time being. So, the real question is, how realistic is the proposed scenario in the opening paragraphs of this paper? Worse, how destructive would an EMP from a nuclear device be if detonated from 250 miles above ground level to populated areas? The present day threat includes not only the proliferation of nuclear weapons and nuclear materials the hands of hostile nations, the threat of which has always existed since the start of the Cold War, but also the increased risk from nations with unstable governments and terrorist organizations. There are several historical examples that will be highlighted to frame the problem and to help answer both of these questions.

One concern with EMP is the fact that it can be caused by naturally occurring phenomena such as from a coronal mass ejection (CME) from the Sun. The National Aeronautics and Space Administration (NASA) define CME as "huge bubbles of gas threaded with magnetic field lines that are ejected from the Sun over the course of several hours."[54] If the CME impacts the Earth's upper atmosphere, depending on the size and magnetic field disruption from the CME, it can cause a geomagnetic storm that can ultimately send a surge of voltage over unshielded electrical power lines and burn out the high voltage transformers critical to the operation of national electric grids.[55] This is essentially the equivalent of the E3 pulse with HEMP from a nuclear explosion. Evidence

[54] Dr. David H. Hathaway, "Coronal Mass Ejections," National Aeronautics and Space Administration, August 14, 2012, accessed July 31, 2014, http://solarscience.msfc.nasa.gov/CMEs.shtml.

[55] Electric Infrastructure Security Council, "Geomagnetic Storms–Information Sheet," February 13, 2013, accessed July 31, 2014, http://eiscouncil.org/English/Resources/ResouceInside.asp?itemId=10431.

of this can be derived from studying the results of the Carrington Event of 1859 and the great geomagnetic storm of 1921. These phenomena are understood to be occurrences throughout the life cycle of average stars, such as our Sun. Though numerous examples exist during the earlier portion of twentieth century,[56] more recent CME examples include the 1989 Quebec Blackout Storm and the U.S.-Canada blackout of August 2003.[57]

The National Academy of Sciences concluded that a recurrence of a 1921-type storm "would result in large-scale blackouts affecting more than 130 million people and would expose more than 350 transformers to the risk of permanent damage."[58] This could cause widespread blackouts, civil unrest, CI/KR damage, and other second and third order effects. Additionally, these effects will most likely overwhelm local law enforcement, strain the Federal Emergency Relief Management Agency (FEMA), and

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[56] Electric Infrastructure Security Council, "Geomagnetic Storms–Information Sheet." The Electric Infrastructure Security Council highlights the following major geomagnetic storm events: "The Carrington Event" (August 28, 1859) which caused worldwide telegraph network failure and fires in some stations, "The Transit of Venus Storm" (November 18, 1882) which disrupted U.S. and British telegraph communications in addition to the Chicago stock market, a geomagnetic storm on November 1, 1903 where telegraph and transatlantic cables where affected, and street cars were disabled, The New York Railroad Storm (May 13, 1921) which caused a fire that destroyed the Central New England Railroad station, The Fatima Storm (January 25, 1938) which disrupted radio and railroads services, The Easter Sunday Storm (March 25, 1940) which caused nearly every long-distance telegraph and telephone office to need repairs, and the February 11, 1958 geomagnetic storm that caused a nationwide radio blackout in the U.S. and cut off U.S. communications with the rest of the world.

[57] Ibid.

[58] The National Academy of Sciences, *Severe Space Weather Events-Understanding Societal and Economic Impacts: A Workshop Report* (The National Academies Press, May 2008), 3, accessed July 31, 2014, http://www.nap.edu/catalog/12507.html.

state level disaster relief capabilities. The U.S. military will likely be called upon to perform its Defense Support of Civil Authorities (DSCA) mission in order to fill or augment any gaps in capabilities within the various civilian disaster relief agencies and organizations.

Definitions

Chemical, Biological, Radiological, and Nuclear Consequence Management (CBRN CM). Actions taken to plan, prepare, respond to, and recover from chemical, biological, radiological, and nuclear incidents.[59]

Coronal Mass Ejection (CME). A massive, bubble-shaped burst of plasma expanding outward from the Sun's corona, in which large amounts of superheated particles are emitted at nearly the speed of light. The emissions can cause disturbances in the solar wind that disrupt satellites and create powerful magnetic storms on Earth. They were first observed in the early 1970s, when photographs taken from satellites revealed coronal activity that could not be seen in images taken from Earth.[60]

Critical Infrastructure and Key Resources (CI/KR). The infrastructure and assets vital to a nation's security, governance, public health and safety, economy, and public confidence.[61]

[59] Chairman of the Joint Chiefs of Staff, Joint Publication 1-02, 34.

[60] The American Heritage Science Dictionary, "coronal mass ejection," Dictionary.com, accessed May 27, 2014, http://dictionary.reference.com/browse/coronal%20mass%20ejection.

[61] Chairman of the Joint Chiefs of Staff, Joint Publication 1-02, 62.

Defense Support of Civil Authorities (DSCA). Support provided by U.S. Federal military forces, Department of Defense civilians, Department of Defense contract personnel, Department of Defense component assets, and National Guard forces (when the Secretary of Defense, in coordination with the governors of the affected states, elects and requests to use those forces in Title 32, United States Code, status) in response to requests for assistance from civil authorities for domestic emergencies, law enforcement support, and other domestic activities, or from qualifying entities for special events. Also known as civil support.[62]

Electromagnetic Pulse (EMP). The electromagnetic radiation from a strong electronic pulse, most commonly caused by a nuclear explosion that may couple with electrical or electronic systems to produce damaging current and voltage surges.[63]

Faraday Cage. A container made of a conductor, such as wire mesh or metal plates, shielding what it encloses from external electric fields. Since the conductor is an equipotential, there are no potential differences inside the container. The metal hull of an aircraft acts as a faraday cage, protecting its occupants from lightning. Faraday cages are used to protect electronic equipment from such electrical interference as electromagnetic interference. Also called Faraday shield.[64]

National Incident Management System (NIMS). A national crisis response system that provides a consistent, nationwide approach for federal, state, local, and tribal

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[62] Ibid., 68.

[63] Ibid., 82.

[64] The American Heritage Science Dictionary, "faraday cage," Dictionary.com, accessed September 14, 2014, http://dictionary.reference.com/browse/faraday%20cage.

governments; the private sector; and nongovernmental organizations to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity.[65]

National Military Strategy (NMS). A document approved by the Chairman of the Joint Chiefs of Staff for distributing and applying military power to attain national security strategy and national defense strategy objectives.[66]

National Security Strategy (NSS). A document approved by the President of the United States for developing, applying, and coordinating the instruments of national power to achieve objectives that contribute to national security.[67]

Scope

The scope of this research thesis will be focused on U.S. strategy and policy on protecting Critical Infrastructure and Key Resources (CI/KR), and how they correlate to the practice of consequence management in the aftermath of an EMP attack. An examination of top-level policy and strategic documents, operational or "middle-tier" policies, and "tactical-level" policies and procedures, will frame U.S. approach to EMP consequence management at each of these tiers. At each of these tiers, a closer look the practical application of these policy documents will discern to what degree the practical application of procedures adhere to the corresponding policies at their respective levels.

[65] Chairman of the Joint Chiefs of Staff, Joint Publication 1-02, 182.

[66] Ibid.

[67] Ibid., 183.

At the strategic level, a look at various Presidential Policy Directives, the National Strategy for Homeland Security, and Homeland Security Presidential Directives will frame the big-picture approach to EMP consequence management. Additionally, the National Security Strategy, and the National Strategy for Physical Protection of Critical Infrastructure and Key Assets, will be used. From a counter-WMD perspective, an examination of the National Strategy to Combat Weapons of Mass Destruction will round out the study of strategic level policies. At this level, the scope of this research will be limited to looking at these documents at their face value. No extrapolation or interpolation of the meaning of these documents will be taken into account, as their end results will manifest themselves in the policies and practices on the smaller scales.

At the operational level, an examination of the policies of the government agencies, namely the Department of Defense (DOD) and DHS, will be made. The DOD and DHS have the largest pool of resources, articulated doctrine, subject matter expertise, and necessary manpower. At this middle-tier, policies and practices will be looked at more closely. In terms of EMP disaster response, a determination of whether policies coincide with practice will be made by examining budgetary focus, allocation of resources, and training. DOD strategic documents such as the Defense Budget Priorities Choices Fiscal Year 2014, the Quadrennial Defense Review 2014, and the National Military Strategy to Combat Weapons of Mass Destruction, will be examined. For the DHS, an examination of the Department of Homeland Security (DHS) Strategic Plan and the National Infrastructure Protection Plans (NIPPs) will be made. Also at this level, an examination of the recommendations made in the Report of the Commission to Assess the Threat to the United States from EMP attack. Reports and recommendations from other agencies such as the Defense Science Board and the Claremont Institute will also be made.

From a tactical level that relates to the small-scale actions conducted in support of the strategic and operational level purposes, the scope of this research will be limited to examining the capabilities and practical applications of this tier in response to research data of the effects of EMP on electrical systems. At this scale, a look at scientific research into EMP, military doctrine on EMP response, and how DHS NIPPs are actually being implemented to mitigate and respond to EMP disaster and consequence management. DHS at this level will mainly be focused on the Federal Emergency Management Agency (FEMA) and its integration of the military in its support role as part of its Defense Support of Civil Agencies (DSCA) mission.

Limitations

The limitations imposed on this thesis are due to availability of open source and decades old historically data that has been declassified. Data from more recent threat data and infrastructure vulnerability assessments are restricted to classification levels beyond the scope of this thesis. Data from government sources, in particular the Congressional Research Service report to the House Armed Services Committee, portioned the testimony from members of the EMP commission into five distinct volumes. Volumes 1 and 3 are the unclassified executive summary and assessment of the U.S. critical infrastructure, whereas volumes 2, 4, and 5 are classified portions that discuss threat assessment and military topics.[68]

Delimitations

Data from the disruptive effects of EMP are documented by astronomers in the case of CME, and from observations recorded following high altitude nuclear testing. Experiments conducted with the Marx Pulse Generator installed at the ATLAS-I (TRESTLE) facility in New Mexico also serves to provide data on the effects of EMP.[69] Astronomical examples, namely data and observations from CME, such as the Carrington event of 1859 and the U.S.-Canada Blackout of 2003, will be used to illustrate some of the second order effects of EMP that caused damage to electrical and communications equipment. Additionally, EMP effects from observed damage from a series of high altitude nuclear tests in 1962 over the Pacific Ocean, particularly “Starfish Prime” as part of Operation Fishbowl, will be used to enhance the reader’s understanding of the magnitude of EMP effects.[70]

The delimitations imposed on this thesis will constrain all source documents and research data to those available to the general public and the unclassified level. This thesis will only cover these case studies enough to clearly describe the documented

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[68] Clay Wilson, *High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices: Threat Assessments* (Washington, DC: Congressional Research Service, July 2008), 2-3.

[69] D. V. Giri and F. R. Graham, *Electromagnetic Characterization of a Marx Pulse Generator* (Albuquerque, NM: Mission Research Corp, 1981), 3.

[70] Wilson, *High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices*, 6.

effects of EMP in order to establish a baseline understanding for the importance of the topic from a national security perspective. Additionally, this thesis will be limited to studying government and military documents in reference to doctrine and practices. Though private sector entities play an important role in EMP consequence mitigation, this thesis will not review the private sector policies and practices beyond that of their direct connection to government and military aspects.

Additionally, the primary reason for delimiting this thesis to open source data is to make this research accessible to the general public with the goal of raising awareness of some of the vulnerabilities that electronics and electrical systems have to EMP. By raising awareness, new research and technology, in conjunction with pre-existing technology, will hopefully be used to harden these systems against the negative affects of EMP. This would best accomplished through efforts by both the private sector and by national governments.

Significance of Study

Critical Infrastructure and Key Resources (CI/KR) comprise of a systems of systems that is profoundly complex and interconnected. These systems run in a harmonious fashion with the specific intricacies being unbeknownst to the average American citizen. The fragile nature of these interconnected and interdependent systems was highlighted with recent events such as Hurricanes Sandy, Katrina, and Rita, and with the U.S.-Canada blackout of 2003. Study into assessing the CI/KR vulnerabilities at the national level due to EMP was addressed by a team of scientists, researchers, and subject matter experts. This was initially conducted and presented to Congress in 2004 by the National Research Council's Committee on EMP Attack. The study brought to light the vulnerability of our CI/KR to EMP and the potential second and third order effects following such an attack.[71] Given the possibility that hostile nations and terrorists may have the means to launch a debilitating EMP strike against the U.S., the importance of understanding U.S. policy and practices in EMP consequence management is critical to national security.

Summary

The vulnerability of the U.S. electrical power grid, computer systems, to include military systems, and electronics to EMP, is widely published in publically available government reports as well as within military doctrine. With the gradual increase of the global proliferation nuclear weapons, the threat of EMP or HEMP based attack against the U.S. becomes an ever-increasing threat to national security. Research and findings conducted by U.S. governmental agencies have concluded that a HEMP attack has the potential to cause extensive damage to unprotected civilian and military electronic equipment for an extended duration of time over a large geographical area. Though an EMP attack itself poses no direct threat to human life, the destruction of electrical systems and electronics on a grand scale can lead to disastrous and unforeseen second and third order affects due to the ubiquitous dependence on electricity and technology.[72]

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[71] Dr. John S. Foster, Jr. et al., *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, Volume 1: Executive Report* (Washington, DC: National Research Council, Committee on Electromagnetic Pulse Environment, 2004).

[72] Wilson, *High Altitude Electromagnetic Pulse (HEMP) and High Power Microwave (HPM) Devices*, 1.

Though the scope of this research will be limited to unclassified sources, the intent is to provide insight into potential shortfalls in practices and generate discussion within a much broader audience than what is limited to government and military circles. Aside from government and military efforts, the civilian and private sector will ultimately play an important role in hardening the electrical grid against EMP threats. As with any threat to U.S. national security, policies and practices need to be firmly established in order to adequately address and mitigate specific threats. This thesis will examine U.S. national policies and practices specifically in regards to EMP consequence management.

CHAPTER 2

LITERATURE REVIEW

Overview

There are numerous documents that address the need to defend against Weapons of Mass Destruction (WMD) and to address post-disaster consequence management. This paper will not address WMD in general terms, but will focus specifically on EMP and its associated effects. Presidential Policy Directives (PPD), Department of Defense (DOD) strategies, and Department of Homeland Security (DHS) strategies all discuss the need for WMD consequence management to varying degrees. These documents provide overarching guidance on at the strategic level or large scale. The level of detail leading to EMP consequence management only becomes apparent at the lowest echelons.

The purpose of this research is to evaluate the U.S. national policies and determine if the practical application of strategy and policy coincide with the level of response needed to manage the consequences associated with an EMP attack. As will be established further in this chapter, specifically addressing EMP consequences become more evident at the lower echelons of government agencies, most notably from within the DOD and the DHS. Secondly, and perhaps more critical to understand, are the potential ramifications of second and third order effects of widespread disruption or damage to the power grid.

Extensive research into the potential effects of EMP, along with recommendations to mitigate infrastructure vulnerabilities, comes from the National Research Council's executive report to assess the treat of EMP attack against the U.S.[73] Additionally, research data from the NASA, and numerous other bodies of science, are pivotal in not only appreciating the critical importance and fragile nature of the electrical power grid, but also in understanding the its vulnerability to EMP and the measures needed to mitigate some of the associated risks.

One of the major vulnerabilities to the electrical power grid is in how the electrical power grid is operated. The grid as it currently operates, runs at near maximum capacity for the sole purpose of increasing profitability. However, this also increases the likelihood of interrupted service, as the grid is more vulnerable to shutting down due to a surge in voltage that exceeds the capacity of the circuit.[74] Additionally, the grid itself contains an assortment of new and old equipment of various manufactures. Spare parts are not stockpiled or readily available and are often produced from overseas manufacturers.

The first and obvious choice is to gather data from subject matter experts in the field of post-disaster consequence management. However, there are many lessons to be garnered from sources outside of the DHS and other governmental agencies that are generally associated with disaster or consequence management. For example, the Army Institute of Dental Research has revealed through experimentation, some of their best

[73] Foster et al., *Electromagnetic Pulse (EMP) Attack. Volume 1*.

[74] B. A. Carreras et al, "Is the Power Grid too Big?," *Chaos* 24, no. 2 (2014), accessed May 7, 2014, http://www.aip.org/publishing/journal-highlights/power-grid-too-big.

practices to mitigating some of the damaging effects of EMP on medical equipment.[75] Though initially, the Army Institute of Dental Research may seem like an unlikely source of applicable data for EMP consequence management, the institution brings a different and value added perspective. The results of their research must be examined to form a comprehensive understanding of the problem, with the goal of coming to a viable solution.

Policy and Doctrine

The military addresses EMP at the tactical level insomuch as to include training publications for specialized service members in the CBRN field to aid in consequence management. Additionally, the DHS provides training at the lowest level to assist personnel in consequence management. Though training and policy guidelines are very necessary, is the current level of national preparedness sufficient to manage the effects of an EMP attack on the homeland? The primary focus of this research paper is to analyze U.S. policies and determine how these policies translate to practical measures in addressing and managing consequences of large-scale electrical grid failure and associated effects resulting from an EMP.

This thesis will categorize U.S. policies and consequence management doctrines into three tiers for the sake of clarity and to aid in the visualization of how each level of policy and doctrine nest with each other and within the overarching theme of homeland security. For example, the National Security Strategy helps to develop the National

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[75] Robert H. Vandre et al., *Minimizing the Effects of Electromagnetic Pulse (EMP) on Field Medical Equipment* (Washington, DC: Army Institute of Dental Research, 1991).

Strategy to Combat Weapons of Mass Destruction. These documents in turn provide the necessary framework and guidance for the development of the military's own strategy to combat WMDs. This military strategy provides the context in which DOD planners use to develop specific plans of action for strategic, operational, and tactical level plans. Figure 4 serves to aid in illustrating how strategic level policy, through a sequence of steps, ultimately translate into actionable plans:

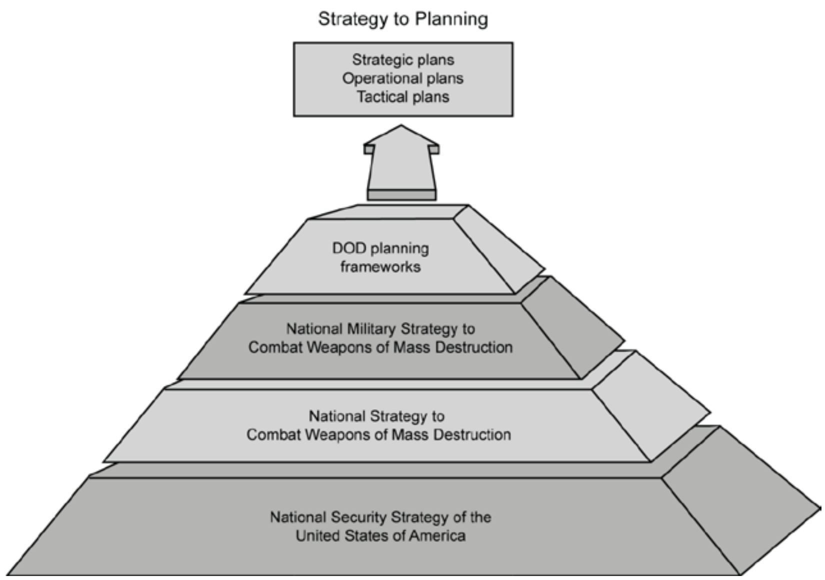

Figure 4. Hierarchy of National Strategy

Source: Headquarters, Department of the Army, Field Manual 3-11, *Multi-Service Doctrine for Chemical, Biological, Radiological, and Nuclear Operations* (Washington, DC: Government Printing Office, July 2011), 2-3.

The National Security Strategy (NSS), issued to the Congress by the President of the United States (POTUS), in broad terms, merely addresses WMD and the threat of nuclear weapons falling into the hands of terrorists and the U.S. commitment to lead the effort in providing security against such threats. The NSS makes note that the commitment to ensuring a secure and resilient nation requires that the infrastructure is built to be more secure and reliable against both natural disasters and terrorist threats.[76] Though the purpose of the NSS is intended to be general in nature, for the purposes of this study, it is notable that the NSS does not specifically address the EMP threat.

Although broad wording is used throughout the NSS, the U.S. diplomatic and economic instruments of national power have been used to bear heavily against hostile states. The Islamic Republic of Iran and the Democratic People's Republic of Korea (DPRK) are two such examples where coercive diplomacy and economic pressure are employed to the fullest extent. For example, the Export Administration Act of 1979 specifically places restrictions on the sale of dual-use items to countries that are state sponsors of terrorism.[77] Dual-use items, by definition, severely restrict trade, as they include any goods, software, or technologies generally used for civilian purposes, but can also be used for military purposes.[78] Since 1979, U.S. sanctions have been the principal means of isolating and compelling Iran to cease support of terrorism. However, this policy evolved in the mid-1990s to pressure Iran to limit the scope of its nuclear program.[79] Similarly, the DPRK is also subject to U.S. and international sanctions. Of

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[76] U.S. President, *National Security Strategy* (Washington, DC: Whitehouse, May 2010), accessed May 8, 2014, http://www.whitehouse.gov/sites/default/files/rss_viewer/national_security_strategy.pdf.

[77] Kenneth Katzman, *Iran Sanctions* (Washington, DC: Congressional Research Service, June 26, 2014), 1, accessed August 3, 2014, http://www.fas.org/sgp/crs/mideast/RS20871.pdf.

[78] Vanderbilt University, "Export Compliance," University Web Communications, 2014, accessed August 3, 2014, http://www.vanderbilt.edu/exportcompliance/definitions.php.

[79] Katzman, *Iran Sanctions*, 1.

note, the DPRK does not comply with international sanctions against Iran. Aside from trade between Iran and the DPRK, both countries cooperate on a wide range of WMD-related ventures.[80]

In addition to U.S. policies directed towards the international community, there are domestic efforts by the U.S. Congress that are intended to address vulnerabilities to the electrical power grid from sources that include EMP. Arizona Congressman Trent Franks introduced House Bill H.R.2417, the Secure High-voltage Infrastructure for Electricity from Lethal Damage Act (SHIELD Act), in June of 2013. The proposed SHIELD Act intends to authorize the Federal Energy Regulatory Commission (FERC) "to order emergency measures to protect the reliability of either the bulk-power system or the defense critical electric infrastructure whenever the President issues a written directive or determination identifying an imminent grid security threat."[81] In addition, the SHIELD Act directs the FERC to consult with governmental agencies in Mexico and Canada, as well as the Electric Reliability Organization in regard to implementation of procedures and recovery measures. Cost savings are expected when all three governments collaborate on emergency measures dealing with bulk-power systems or the protection of critical electrical infrastructure.[82] House Bill H.R.2417 also intends to mandate that the Secretary of Energy establish programs that will "develop technical expertise in the

[80] Ibid., 36.

[81] U.S. Congress, *Secure High-voltage Infrastructure for Electricity from Lethal Damage Act*, H. Res. 2417, 113th Cong., 1st sess., June 18, 2013.

[82] Ibid.

protection of electric energy systems against either geomagnetic storms or malicious acts using electronic communications or electromagnetic weapons."[83]

As of this writing,[84] House Bill H.R.2417 has not been passed into law. However, it is not the only bill that was introduced to address power grid vulnerabilities. Congressman Franks also introduced House Bill H.R.3410, Critical Infrastructure Protection Act (CIPA), in October 2013.[85] CIPA intends to amend the Homeland Security Act of 2002 to address critical infrastructure vulnerabilities to EMP on several fronts. First, CIPA intends to address the threat of EMP events by mandating that the Assistant Secretary of the National Protection and Programs Directorate include EMP in disaster management planning scenarios.[86] Secondly, CIPA also focuses on education and training by directing the DHS to "conduct a campaign to proactively educate owners and operators of critical infrastructure, emergency planners, and emergency responders at all levels of government of the threat of EMP events."[87] In addition to planning scenarios and training, CIPA also intends to direct the Under Secretary for Science and Technology to conduct additional research on EMP effects on critical infrastructure. Other mandated tasks include the prioritization of critical infrastructure security efforts, and to make recommendations on technology and emergency planning by consulting with subject

[83] Ibid.

[84] November 30, 2014.

[85] U.S. Congress, *Critical Infrastructure Protection Act,* H. Res. 3410, 113th Cong., 1st sess., October 30, 2013.

[86] Ibid.

[87] Ibid.

matter experts in both the government and private sectors.[88] Overall, the intent of CIPA is to increase the knowledge base, bolster awareness, and develop a comprehensive plan for the protection of critical infrastructure through collaborative efforts between the government and private sectors to specifically address threats from EMP. Like the SHIELD Act, CIPA has not yet been passed into law.

In addition to the SHIELD Act and CIPA, both the U.S. Congress and U.S. Senate have recently introduced the Grid Reliability and Infrastructure Defense Act (GRID Act). The GRID Act was introduced by both Congressman Henry A. Waxman as House Bill H.R.4298[89] and by Senator Edward J. Markey as Senate Bill S.2158[90] in March of 2013, respectively. Very similar to what was introduced in the SHIELD Act, the GRID Act intends to give the FERC authorization to carry out emergency measures to safeguard bulk-power systems or the defense critical electrical infrastructure. Additionally, if an imminent threat to the power grid is identified, the POTUS is to issue a written directive to order emergency measures to protect the reliability of either the bulk-power systems or the defense critical electrical infrastructure.[91] As with the SHIELD Act and CIPA, the GRID Act also places emphasis on training and collaboration with Canadian and Mexican authorities by mandating that appropriate information be shared and joint efforts

[88] Ibid.

[89] U.S. Congress, *Grid Reliability and Infrastructure Defense Act*, H. Res. 4298, 113th Cong., 2nd sess., March 26, 2013.

[90] U.S. Congress, *Grid Reliability and Infrastructure Defense Act*, S. Res. 2158, 113th Cong., 2nd sess., March 26, 2013.

[91] Ibid.

towards developing protocols aimed at protecting bulk-power systems be implemented.[92] As of this writing,[93] the GRID Act has yet to be passed into law.

It is important to note that the SHIELD Act, CIPA, and GRID Act were all introduced in 2013, which is five years from which the final report on threat assessment of EMP attack on critical national infrastructure which brought to light serious vulnerabilities of CI/KR in the U.S.[94] Additionally, these bills were introduced nine years from when the initial findings and executive report on EMP threat[95] where presented to Congress by the Dr. John S. Foster, Jr. and his colleagues. In 2009, years prior to the introduction of these bills, former Speaker of the House, Newt Gingrich, along with author William R. Forstchen brought the topic of EMP's potential threat to national security and critical infrastructure to the foreground with the New York Times best selling book, "One Second After."[96] Even though there was little action by government and the private sector at the time, the current efforts to address the issue of EMP vulnerability is a bi-partisan effort. The SHIELD Act and CIPA being sponsored by Republicans and the GRID Act sponsored by Democrats in both the House of

[92] Ibid.

[93] November 30, 2014.

[94] Foster et al., *Commission to Assess Threat from EMP*.

[95] Foster et al., *Electromagnetic Pulse (EMP) Attack. Volume 1*.

[96] Newt Gingrich, "Newt Gingrich: Preparing for the next outage," *The Washington Post*, July 12, 2012, accessed August 17, 2014, http://www.washington post.com/opinions/newt-gingrich-preparing-for-the-next-outage/2012/07/12/ gJQAI1QQgW_story.html.

Representatives and Senate illustrates that the importance of safeguarding CI/KR transcends political party lines.

The DOD uses the National Military Strategy (NMS) to form its strategic approach from a military perspective. The strategic approach to providing for the security of the nation is the cornerstone of the NMS. The NMS specifically mentions that the "intersection between states, state-sponsored, and non-state adversaries is most dangerous in the area of WMD proliferation and nuclear terrorism."[97] The section on WMD goes further as to mention specifically the threat from North Korea and a nuclear-armed Iran.[98]

Additionally, the NMS acknowledges the risks associated with multiple nuclear-armed regimes in the Middle East. Specifically, the associated risks are the lack of security and command-and-control mechanisms, which increases the overall threat of the loss of control of a nuclear weapon to non-state actors.[99] The DOD's strategy is clearly more focused on the threat of WMD, particularly the potential for nuclear weapons falling in to the hands of hostile non-state actors.

Focusing on the threat of nuclear weapons being used by rogue states is certainly valid concern for the DOD. Of particular concern, over the past ten years Iran has made substantial strides towards having viable nuclear weapons.[100] If the diplomatic instrument

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[97] U.S. Department of Defense, *The National Military Strategy of the United States of America* (Washington, DC: U.S. Department of Defense, 2011), accessed May 8, 2014, http://www.army.mil/info/references/docs/NMS%20FEB%202011.pdf.

[98] Ibid.

[99] Ibid.

[100] Alexander K. Bollfrass, *Domestic Contraints and Drivers of U.S. Nuclear Policy* (Washington, DC: Center for Strategic and International Studies, 2012), 64.

of national power were to ultimately prove unsuccessful, the DOD could potentially be thrust into the limelight as the primary means to remove the threat of nuclear weapons. U.S. Congressman Roscoe Bartlett emphasized that sophisticated intercontinental ballistic missiles are not a prerequisite for the execution of an EMP attack. Short and medium range missiles, such as a Scud or the Iranian Shahab-3, can easily use a freighter as viable launch platform. Bartlett also noted that Iran has already practiced this method by test firing a missile off a ship in the Caspian Sea.[101]

In addition to Iran, North Korea or the DPRK, is a rogue state of great concern to the DOD. Since their detonation of a nuclear device on October 9, 2006, the office of the Director of National Intelligence initially assessed the test as a sub-kiloton weapon that probably did not have significant potential as an EMP weapon.[102] However, the EMP Commission's research concluded "certain types of relatively low-yield nuclear weapons can be employed to generate potentially catastrophic EMP effects over wide geographic areas."[103] Additionally, weapon design technology for EMP has likely been trafficked through illicit channels during the last 30 years.[104]

The use of EMP by the Russian Federation also poses a significant threat. During NATO led operations against Serbia in 1999, members of Russia's legislative body, the

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[101] Dr. Mark Schneider, "The Emerging EMP Threat to the United States," National Institute for Public Policy, November 2007, accessed August 17, 2014, http://www.worldaffairsboard.com/attachments/rise-china/13217-prc-anti-access-strategy-discuss-post-up-articles-pdfs-etc-china-emp-paper-schneider.pdf.

[102] Ibid., 10.

[103] Foster et al., *Electromagnetic Pulse (EMP) Attack. Volume 1.*

[104] Ibid.

Russian Duma, openly threatened the U.S. with an EMP strike.[105] Congressman Roscoe G. Barlett recorded the following encounter in 1999:

> We met with three of our Russian counterparts on the Duma International Affairs Committee, including its chairman, Vladimir Lukin, and senior Communist Party member Aleksandr Shabonov. On May 2, [1999] the Russians chastised the United States for military aggression in the Balkans and warned Russia was not helpless to oppose Operation Allied Force. Lukin said, 'If we really wanted to hurt you with no fear of retaliation, we would launch an SLBM [submarine launched ballistic missile] and detonate a single nuclear warhead at high altitude over the United States and shut down your power grid and communications for six months or so.' Shabonov added, 'And if one weapon wouldn't do it, we have some spares.'[106]

Though this may appear to be standard sabre rattling between rival superpowers, it does serve to highlight that if armed conflict were to erupt between the U.S. and Russia, the use of EMP is certainly within the realm of possibility.

The Russian Federation is not the only superpower that fully understands the use of EMP as a weapon to attack U.S. interests. In fact, the People's Republic of China has studied the use of nuclear EMP for several decades as a means within their strategy to retake Taiwan.[107] Additionally, there is a concern about the possible use of EMP strikes against the U.S. if it acts to intervene on behalf of Taiwan. Reports from Chinese military analysts revealed that China has "developed electromagnetism pulse bombs."[108] The Chinese fully understand the potential of EMP attacks and the vulnerability modern

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[105] Schneider, "The Emerging EMP Threat to the United States," 3.

[106] Ibid.

[107] Ibid., 6.

[108] Ibid.

electronics have and the U.S. dependency on such technology. Chung Chien wrote a brief synopsis of China's EMP capabilities in Taiwan as follows:

> The PLA [People's Liberation Army] now possesses a matured vehicle carrying [a] low-yield nuclear weapon to detonate at the appropriate height, that is the battletested, combat-ready Dong Fong-15 (M-9 for export version) short range ballistic missile (SRBM). The nuclear EMP attack creates an extremely high electric field of 10,000 volts per meter, covering up to 100 km from ground zero. The sudden onset of electric field can cause permanent damage on electronic devices containing micro memory chip, logic circuit, integrated circuit, diode, transistor, and amplifier as well, virtually shut down all C4ISR[109] equipment used by both military and civilian communities.[110]

The U.S. currently enjoys the status of being the most technologically advanced power in the world. The Chinese are fully aware of the critical vulnerability that dependency on technology can lead to. If armed conflict were to arise in which the limited usage of nuclear weapons were to take place, the use of EMP strikes at the tactical and operational level are planning factors within their overall military strategy.[111]

The NMS not only focuses on defense of the homeland in a military sense, they also focus on playing a vital role in supporting homeland security. The implementation of the NMS is vitally important in addressing the aforementioned threats from hostile nations and non-state actors with a nuclear EMP strike capability. In the homeland security role, the DOD works with DHS, state and local governments, and non-governmental organizations to provide planning capabilities, command-and-control, consequence management, and logistical support. NMS also states that the DOD will

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[109] C4ISR stands for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance.

[110] Schneider, "The Emerging EMP Threat to the United States," 6.

[111] Ibid.

dedicate, fund, and train a portion of the National Guard for homeland defense.[112] Additionally, all the associated missions and requirements with its Defense Support of Civil Authorities (DSCA) role is emphasized by planned integration of interagency partners as part of the overall approach.[113] As noted in the NSS, the NMS does not specifically address the EMP threat. However, the DSCA role is an important step towards understanding the DOD's role in augmenting other governmental agencies in disaster relief efforts and consequence management.

Essentially, the development of a viable doctrine that is designed to counter or mitigate the threat of EMP strikes against the U.S. needs to take into account three key elements. First, a careful look at historical data needs to take place in order establish a baseline knowledge on EMP effects and employment as a weapon. Secondly, the application of theory in the form of scientific research, as informed by sufficient data and adequate resourcing, is used to understand various effects and ways EMP can be employed. Finally, the formation of doctrine is the culmination and synthesis of data and theory. This doctrinal framework provides the methodology and common practices needed in which all entities responsible for EMP threat mitigation and consequence management can operate from.

Practical Applications

The practical application of policy and doctrine manifests itself in several ways. First is the national level effort placed on research into understanding the intricacies of

[112] U.S. Department of Defense. *The National Military Strategy*, 10-11.

[113] Chairman of the Joints Chiefs of Staff, Joint Publication 3-27, *Homeland Defense* (Washington, DC: Government Printing Office, 2013), I-9.

the potential damaging effects of EMP in addition to the development of means to safeguard equipment against this threat. Secondly, the relationship between policy and doctrine serves as a catalyst to drive the actions and overall level of preparedness of military forces and civilian agencies. Thirdly, the allocation of resources in terms of manpower and funding towards EMP consequence management can also serve as an indication of the level of practical support by the U.S. government.

Research and development yield information and theories that drive doctrine. However, doctrinal requirements and identified gaps in knowledge serve to drive further research. This give and take relationship establishes a certain level agility to efforts supporting EMP threat mitigation and consequence management. For example, the National Infrastructure Simulation and Analysis Center (NISAC) was responsible for providing infrastructure scenario modeling and analysis.[114] The NISAC conducted experiments to study a possible EMP attack scenario involving a large EMP source off of the California coastline. This experiment involved simulations that encompassed the effects of EMP exposure on various interconnected infrastructure systems.[115] The data derived from this effort yielded information on how telecommunication systems, data networks, information transfer, banking and financial market systems would be affected. In addition, the simulation also examined the effects on CI/KR such as those involving water distribution, electrical power, the petroleum and natural gas infrastructure.[116]

[114] Foster et al., *Commission to Assess Threat from EMP*, 12.

[115] Ibid., 15.

[116] Ibid.

The modeling and data gleaned from the NISAC experiments attempted to link the various infrastructure interactions with transportation, labor, and economic aspects. However, the experiment lacked realism because it did not take into account the likelihood of physical damage and the associated impediment it could pose to recovery processes.[117] Nevertheless, the experiment was value added in that it provided some insight into how a failure of one system within a particular infrastructure could have cascading affects on other interconnected systems. This is important to note because it reveals that even limited damage to infrastructure by EMP can still have the ability to cause much broader disruption to adjacent infrastructures and systems.[118]

Prior to 1991, EMP simulation testing and experimentation also was conducted at the ATLAS-I[119] (TRESTLE) facility in New Mexico by the U.S. Air Force Weapons Laboratory. At this facility, a Marx Pulse Generator was used to study and measure the effects of high intensity EMP. Additional research included the design characteristics of and physical properties of the pulse generator itself.[120] The primary research focus conducted at the ATLAS-I facility was to study the effects of destructive EMP on aircraft. The program was shutdown after the end of the Cold War and subsequent testing

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[117] Ibid.

[118] Ibid.

[119] ATLAS-I is the abbreviation for the Air Force Weapons Lab Transmission-Line Aircraft Simulator.

[120] Giri, *Electromagnetic Characterization of a Marx Pulse Generator*.

of this type is now limited to computer simulations.[121] The specific details are highly technical in nature and are beyond the scope of this thesis. However, the data may prove to be invaluable for further research.

EMP research data can also come from sources that may not seem immediately obvious. The U.S. Army Institute of Dental Research conducted EMP simulator testing and computer simulations to discern the impact EMP would have against medical equipment. Their research concluded that approximately 65 percent of unprotected medical equipment can experience damage from a single nuclear explosion as far as 2,200 kilometers away.[122] Additionally, some of the damage mitigation measures discovered over the course of their experiments were relatively easy to accomplish. Such measures included proper grounding of equipment as well as keeping cabling close to the ground. Their research revealed that by keeping electrical wiring short, unplugging unused equipment, running power cabling and tents in a magnetic North-South orientation can offset some of the destructive effects of EMP.[123]

In addition to research, some of the other practical applications involve actions that establish an overall level of preparedness of military forces and civilian agencies as it relates to policy and doctrine. FEMA routinely conducts exercises based on plans that were developed for the execution of real world incident response. The DHS NIPP of 2013, Partnering for Critical Infrastructure Security and Resilience, establishes seven

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[121] Charles Reuben, "In Memoriam: Empire My Prince: Carl Baum, trestle-maker," *Weekly Alibi* 20, no. 1 (January 6, 2011), accessed September 15, 2014, http://alibi.com/news/35291/Empire-My-Prince.html.

[122] Vandre et al., *Minimizing the Effects of EMP on Medical Equipment*, 3.

[123] Ibid.

core tenets that highlights some important planning considerations. The planning considerations are broad enough in scope as to have applicability across the national, regional, state and local levels, and owner and operator levels.[124]

The seven core tenets emphasize risk mitigation through effective management coordination and cooperation efforts. One key component involves information sharing that serves to enable the effective allocation of security and other resources. In order to facilitate this effectively, the core tenets specially mention the liaison relationship that needs to be established between the private sector and with government agencies. The partnership approach to risk management and security is grounded in gaining knowledge and understanding of cross-sector dependencies and interdependencies of critical infrastructure.[125] A facet that ties all of these tenets together is the goal that these planning factors and partnerships be incorporated into the design of assets and systems throughout all actionable plans and efforts down to the lowest level.[126]

DHS and DOD subordinate agencies conduct large-scale disaster response exercises periodically. Though these exercises by the military and FEMA have never been catered to specifically provide a response scenario to an EMP disaster on a national level, there are many lessons learned from these exercises. Various aspects of the respective consequence management doctrines can be tested for viability and refined as

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[124] Department of Homeland Security, NIPP 2013, *Partnering for Critical Infrastructure Security and Resilience* (Washington, DC: Department of Homeland Security, 2013), 13, accessed May 4, 2014, http://www.dhs.gov/sites/default/files/publications/NIPP%202013_Partnering%20for%20Critical%20Infrastructure%20Security%20and%20Resilience_508_0.pdf.

[125] Ibid.

[126] Ibid., 14.

shortfalls or gaps are identified. More importantly, the coordination and liaison relationships between all echelons were identified as common lessons learned from both the DOD and the DHS as they interacted with a host of private sector entities.

Within the DHS, FEMA conducted a tabletop exercise in 2011 based on real world events where the exercise scenario consisted of critical power failures spanning across multiple states, coupled with the effects of severe weather events.[127] This particular disaster scenario exercise was designed to incorporate the local communities into FEMA's own disaster relief efforts. The purpose of this scenario was to build community relationships as well as ascertain how well FEMA's emergency plans nest with particular community's plan. The exercise helped to identify gaps in support such as telecommunications, utilities, water, food and fuel distribution, and areas designated for shelters.[128] Additionally, the exercise tested how well the public and private sector interacted, as well as evaluated previously existing planning assumptions. Participants were encouraged to improvise and be adaptive to changes within the scenario, especially when reacting to evacuations, and displaced persons ranging in the tens of thousands in the various population centers.[129] Response times were tested through the use of traditional methods such as phone and radio. FEMA also monitored Twitter feeds in

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[127] Federal Emergency Response Agency, "Emergency Planning Exercises," July 24, 2014, 2, accessed September 15, 2014, http://www.fema.gov/pdf/privatesector/ps_notes_ttx_power.pdf.

[128] Ibid.

[129] Ibid., 7.

order to enhance the overall situational awareness and ultimately bolster coordination efforts with local law enforcement and various community led efforts.[130]

The Halo Corporation security firm conducted one unconventional approach to disaster response training in 2012 as part of the company's annual counterterrorism summit. This particular exercise, funded by The Homeland Security Grant Program and the Urban Areas Security Initiative, used a mock "Zombie Apocalypse" disaster-crisis scenario in the 5-day training event. The training included the DHS, DOD, Centers for Disease Control and Prevention, and various law enforcement agencies.[131] Though this may seem whimsical and perhaps a waste of time and resources, the exercise itself had merit. The exercise coordinators saw this training scenario as a way to apply teaching points that have applicability to real world events in a fun way. The scenario highlighted some elements that could be similar to natural or manmade disasters such as unpredictability and asymmetric threats.[132] In an exercise such as this, unpredictability is one element that stresses the coordination efforts of all agencies involved. The lessons gained from this mock exercise can be applied to larger scale disasters such as EMP.

DOD and DHS training exercises for disaster response is small scale compared to the potential damage and disruption of power caused by HEMP. Additionally, the assumption is that technology and some form of infrastructure will be available to

[130] Ibid., 18.

[131] Gidget Fuentes, "Zombies a Training Tool at Counterterror Event," *Army Times*, September 19, 2012, accessed September 15, 2014, http://www.armytimes.com/article/20120919/NEWS/209190328/Zombies-training-tool-counterterror-event.

[132] Julie Watson, "Marines, Police Prep for Mock Zombie Invasion," Associated Press, October 27, 2012, accessed September 16, 2014, http://www.federalnewsradio.com/473/3096034/Marines-police-prep-for-mock-zombie-invasion.

conduct operations. Though alternative communication methods, such as using Twitter or other forms of social media, have been used to increase situational awareness during a disaster, these methods are likely to be unavailable following the aftermath of an EMP strike. Most communication systems are dependent on a functioning electrical grid. Even systems that are not directly connected to the grid will eventually require electrical power to recharge batteries, assuming that these communications systems have somehow avoided the damaging effects of EMP altogether.

In light of the potential for major disruptions to standard communication methods between FEMA and other disaster response agencies, the criticality of establishing and maintaining liaison relationships with community leaders becomes readily apparent. FEMA understands the importance of enhancing their consequence management capability by enlisting the aid of voluntary, faith-based, and community-based organizations.[133] Some of the benefits of this method include local level expertise, crisis counseling, warehousing, preliminary damage assessments, and messaging capabilities in the absence of grid power or modern communications technology. Also at the local level, the establishment of long-term volunteer recovery teams could prove to be an invaluable asset as part of a larger disaster relief effort.[134]

Another practice by FEMA is the agency's emphasis on individual preparedness. In light of response times to aid and rescue efforts during recent natural disasters such as Hurricanes Katrina and Sandy in 2005 and 2012 respectively, individuals that had the

[133] Federal Emergency Management Agency, "Voluntary, Faith-Based, and Community-Based Organizations, " September 11, 2014, accessed September 15, 2014, http://www.fema.gov/voluntary-faith-based-community-based-organizations.

[134] Ibid.

recommended emergency supplies on hand did not require immediate government assistance. Logistics efforts face additional strain when faced with urgent timelines for required resources as well as on the various capabilities needed for the distribution of these resources to the individuals and families in dire need of basic essentials. Better prepared individuals and families during a crisis place much less strain on disaster relief logistics by allowing additional, and often much needed, time for the flow of resources to take place. Additionally, first responders would have the ability to focus on cases that were unavoidable or more critical, as opposed to having to rescue individuals that made the choice to be ill-prepared.

FEMA provides a wealth of resources catered towards enhancing awareness and emergency preparedness. Resources such as training are available to the public in various forums. Additionally, FEMA provides guides on how to plan for, mitigate, and prepare for disasters in a multitude of ways. FEMA is also forward leaning when it comes to leveraging technology by creating smart phone applications, online training videos, and having a robust presence on social media.[135] FEMA's Ready.gov website in particular, is a very good example of how information on individual preparedness is being made accessible to as broad an audience as possible. For instance, Ready.gov is currently translated into twelve languages to aid in providing information to various minority or immigrant communities. Additionally, there is preparedness information catered specifically for the needs of businesses, children, and even pets.[136]

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[135] Federal Emergency Management Agency, "Plan, Prepare and Mitigate," July 18, 2013, accessed September 17, 2014, http://www.fema.gov/plan-prepare-mitigate.

[136] FEMA/Ready.gov, "Prepare, Plan, Stay Informed," accessed September 17, 2014, http://www.ready.gov/.

The DOD also conducts large-scale annual training exercises such as Global Guardian and Vigilant Guardian. These exercises are both sponsored by the United States Strategic Command in conjunction with Air Force Space Command, and North American Aerospace Defense Command (NORAD) and are structured to towards a nuclear attack scenario and threat to U.S. airspace.[137] The exercises themselves were designed to be as realistic as possible. The Vigilant Guardian exercise was revealed to have a high level of realism as was highlighted in the 9/11 Commission Report presented to the POTUS and U.S. Congress on July 22, 2004.[138] The following excerpt from the report illustrates this point:

> On 9/11, NORAD was scheduled to conduct a military exercise, Vigilant Guardian, which postulated a bomber attack from the former Soviet Union. We investigated whether military preparations for the large-scale exercise compromised the military's response to the real-world terrorist attack on 9/11. According to General Eberhart, "it took about 30 seconds" to make the adjustment to the real-world situation. Ralph Eberhart testimony, June 17, 2004. We found that the response was, if anything, expedited by the increased number of staff at the sectors and at NORAD because of the scheduled exercise.[139]

Though the level of response to a terrorist attack involving hijacked aircraft was rapid due to the increased staffing during the exercise, it clearly demonstrates that NORAD has the capacity to respond quickly to an unexpected situation. These exercises play an important role in measuring the performance of command and control, coordination, and responsiveness of the military and civilian agencies. However, the level of response

[137] Wikipedia, "Global Guardian," last modified December 23, 2013, accessed October 27, 2014, https://en.wikipedia.org/wiki/Global_Guardian.

[138] Thomas H. Kean et al., *The 9/11 Commission Report, National Commission on Terrorist Attacks Upon the United States*, July 22, 2004, accessed October 27, 2014, http://govinfo.library.unt.edu/911/report/911Report.pdf.

[139] Ibid., 458.

required to address a nuclear or EMP attack, and the associated second and third order effects, remains untested.

Aside from exercises and planning for incident response, the physical design and organizational component of the U.S. national electrical power grid has some critical flaws and vulnerabilities, though steps are being made to alleviate some of these shortfalls. The North American Electrical Reliability Corporation (NERC) was established following the 1965 Northeast Power Failure[140] to provide expertise and oversight of the integrated power system of the U.S., Canada, and Mexico. At present, this vast electrical network is divided into three separate systems and is electrically separated from one another for most part. This separation serves as a barrier against major system disruptions from crossing between regions.[141]

The subregions depicted within the Eastern Interconnection on Figure 5 are for organizational, record keeping, and other administrative functions.[142] It is important to note that even though these three interconnections are separated electrically, they currently lack frequency independence from one another. This translates into the fact that whole regions can still be made to collapse if a strong enough EMP were to trigger a cascading failure of enough systems across an extensive geographical area.[143]

Figure 5 depicts the current NERC interconnections. An example of a widespread systems failure due to shortfalls within the NERC interconnections framework was

[140] Foster et al., *Commission to Assess Threat from EMP*, 20.

[141] Ibid., 24-25.

[142] Ibid., 25.

[143] Ibid.

revealed by the of the 2003 U.S.-Canada blackout case study, which will be discussed in further detail in the following section of this paper. Additonally, the above-mentioned case study will discuss how some of the vulnerabilities that were revealed have direct implications to the threat posed by EMP.

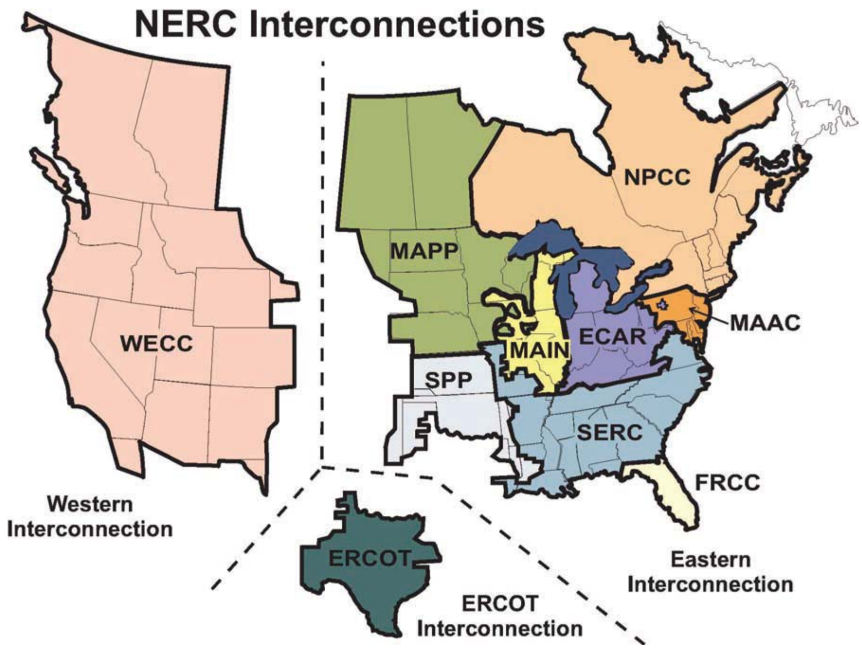

Figure 5. NERC Interconnections

Source: Dr. John S. Foster, Jr. et al., *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Critical National Infrastructures* (McLean, VA: Electromagnetic Pulse (EMP) Commission, 2008), 25.

Deficiencies in computer and cyber systems were areas of concern in the 2003 U.S.-Canada blackout case study. Of note, policies and procedures regarding the upgrade and maintenance of critical command and control systems, as well as subsystems such as SCADA were analyzed. Additionally, the policies surrounding contingency planning and restoration of key computer systems in the event of failure was studied.[144] Another area that was of concern was the heating, ventilation and air conditioning, and supporting telecommunications network subsystems which serve to maintain the proper operating environmental conditions for various electronic and computer systems.[145]

There are a multitude of other shortfalls identified as a result of this widespread blackout. Ultimately, the recommendations resulted in changes in legislation designed to strengthen the reliability of critical power infrastructure by way of mandatory and enforceable standards, with penalties for noncompliance. One such change is that the NERC was established as the institution that was responsible for developing and enforcing reliability standards. Additionally, the NERC was granted the legal authority to enforce these standards on any U.S. power company that it found to be non-compliant by way of fines.[146]

Case Studies

The interconnected characteristics of CI/KR are unavoidably linked to the human dimension in multiple ways. Two case study examples will be presented in regard to the human casualties directly related to power disruption. The first case study will discuss health related deaths that occurred as a direct result of power disruption. The second case

[144] Nils J. Diaz et al., "Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations," U.S.-Canada Power System Outage Task Force, April 2004, 135-136, accessed October 26, 2014, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/BlackoutFinal-Web.pdf.

[145] Ibid., 136.

[146] Whatis.com, "North American Electric Reliability Corporation (NERC)," TechTarget.com, March 2010, accessed October 26, 2014, http://whatis.techtarget.com/definition/North-American-Electric-Reliability-Corporation-NERC.

study will discuss an example of the lawlessness and resultant second and third order effects that transpired during a short period power blackout.

Additionally, two other case studies will discuss examples of the physical damage that EMP can cause. The third case study will give specific examples of early Cold War nuclear weapons testing and the damaging effects of EMP on electrical systems. The fourth case study will focus on SCADAs and how these systems present a critical vulnerability to CI/KR as a whole.

The final case study uses the 2003 U.S./Canada blackout as an example of regulatory and policy concerns. Additionally, this final case study identifies shortfalls in current practices as well as revealing some of the best practices learned from this incident as it may apply to future power disruptions over a large geographical region.[147] All of these case study examples have various components that are expected to occur during and after a HEMP incident that triggers regional power disruption and damage to infrastructure.

Modern society has grown increasingly reliant on electrical infrastructure and its associated subsystems. Once considered a luxury item, modern air conditioning has established itself as a necessity. The boom in air conditioning usage in the common household started in the early 1950s.[148] Since then, population growth in the hotter parts of the United States has greatly increased. Modern home designs have also shifted from

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[147] Diaz et al., "Final Report 2003 U.S.-Canada Blackout."

[148] Jeff Nilsson, "Air Conditioning: From Luxury to Necessity," *The Saturday Evening Post*, July 31, 2010, accessed October 19, 2014, http://www.saturdayevening post.com/2010/07/31/history/post-perspective/air-conditioning-luxury-necessity.html.

having the ability to naturally circulate air through the use of breezeways and strategically placed windows, to a design wholly dependent on central air conditioning.[149]

This first case study will show how a heat wave in conjunction with widespread power disruption can prove to be a deadly combination. One of the negative side effects of having a near perfect artificial climate year-round is that citizens that are not as resilient to withstand heat due to lack of being acclimatized. This becomes more evident in modern times with power outages occurring during the summer months. One notable report by the Centers of Disease Control indicated that a widespread blackout across four states during a period of hot weather that exceeded 100 degrees Fahrenheit, caused fatalities to the physically vulnerable.[150] Thirty-two cases of heat exposure related deaths were reported during June 30, 2012 to July 13, 2012. The report stated the following:

> Common underlying or contributing conditions included cardiovascular disease (14) and chronic respiratory disease (four). In at least seven (22%) of the deaths, loss of power from the storms was known to be a contributing factor. Overall, 22 (69%) decedents died at home, with lack of air conditioning reported in 20 (91%) of these deaths. In the homes of five persons who died, a functioning air conditioner was present but not turned on. Of the seven deaths in which housing type was specified, six occurred in multifamily dwellings. Heat exposure occurred outdoors in three deaths, and two deaths occurred in a vehicle.[151]

This report clearly shows the vulnerability of certain segments of the population, notably unhealthy individuals as well as the elderly. Dangerous conditions similar to the above example are possible side effects from an EMP induced widespread electrical grid failure

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[149] Ibid.

[150] Centers for Disease Control and Prevention, “Heat-Related Deaths After an Extreme Heat Event - Four States, 2012, and United States, 1999–2009,” Morbidity and Mortality Weekly Report (MMWR), June 7, 2013, accessed October 19, 2014, http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6222a1.htm.

[151] Ibid.

during summer months. Additionally, extensive and lengthy power disruption during the winter months can also prove to be equally as hazardous, especially for the more vulnerable or ill-prepared segments of the population.

This second case study will highlight an example of the lawlessness and resultant second and third order effects of a relatively short-term disruption to power. The vast majority of people have experienced temporary disruptions to electrical power at one time or another, usually due to weather. Typically, power is restored in a timely fashion and there is minimal, if any, damage. However, this is not always the case. In this particular case study example, the 1977 New York City blackout revealed that the second and third order effects were as unpredictable as they were costly.[152]

In 1977, lightning struck a power substation along the Hudson River, which tripped two circuit breakers and caused a twenty-four hour blackout that affected the entire New York City metropolitan area. Though various fail-safes were in place, operator error and maintenance shortfalls in conjunction with a critical portion of infrastructure being struck, resulted in a series of cascading subsystems to fail resulting in the entire New York City grid to lose power.[153] During this time, the city itself was facing economic difficulties, almost to the point of bankruptcy. The combination of financial hardship and power failure in a densely populated area resulted in a temporary societal breakdown.[154]

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[152] Tony Long, "July 13, 1977: Massive Blackout Plunges New York Into Rioting," Wired.com, July 13, 2010, accessed October 25, 2014, http://www.wired.com/2010/07/0713massive-blackout-hits-new-york/.

[153] Ibid.

[154] Ibid.

The rioting, looting, fire, and vandalism that ensued throughout the city resulted in an estimated $300 million in damages. In total, over a thousand fires were set and 1,616 stores were either looted or damaged. Additionally, law enforcement ended up arresting 3,776 people during the blackout. The mass arrests that overwhelmed the capacity of jails resulted in improvised holding facilities being used, such as precinct basements and other ad hoc locations.[155]

Though events like the 1977 New York City blackout are the exception to the norm, the longer a disruption of power in a major metropolitan area is, the likelihood of other essential services, such as water distribution, will become unavailable. This is due in part to the limited capacity of backup power generation at critical pieces of infrastructure, such as for water and sewage. The probability of civil unrest increases, as people will likely want to exploit the fact that law enforcement capabilities during a longer-term blackout will be more heavily strained. The possibility of looting, fires, injuries, and property damage will only serve to exacerbate the strain on law enforcement and efforts to restore essential services and rule of law.

The third case study will look at the some of the unexpected observations of nuclear weapons based EMP during the height of the Cold War. Nuclear weapons testing in the 1960s caused some significant unforeseen consequences at the time. In 1962, the U.S. detonated a thermonuclear weapon over the Pacific Ocean at an altitude of approximately 400 kilometers. This particular nuclear test, code named Starfish Prime, was not specifically designed to produce enhanced EMP effects. However, even the relatively low level EMP from the Starfish Prime test resulted in damage to electrical

[155] Ibid.

systems in Hawaii, located over 1,400 kilometers away. Damage included the "failure of streetlighting, systems, tripping of circuit breakers, triggering of burglar alarms and damage to a telecommunications relay facility."[156]

Also in 1962, the Soviet Union conducted high altitude nuclear weapons testing that resulted in unexpected damage from EMP. In this particular case, the Soviets detonated a 300 kiloton weapon in space that damaged "over head and buried cables at [a] distance of 600-kilometers,"[157] and resulted in "surge arrestor burnout, spark-gap breakdown, blown fuses, and power supply breakdowns."[158]

In both cases, the average electrical devices of the time were more robust and resilient in regard to resisting damage from fluctuations in voltage. The damage and preliminary data and assessments made about these tests prompted a unilateral agreement in 1963 to ban nuclear weapons tests high above the Earth's surface. The Test Ban Treaty of 1963 resulted in the prohibition of nuclear weapons tests, to include nuclear tests not in the form of weapons, in the atmosphere, in outer space, and under water.[159]

The concept of nuclear deterrence between nations has been shown to hold true since the dawn of the nuclear age. The data from the high altitude nuclear tests from the 1960s has shown that EMP as a weapon is to be treated in much the same way a traditional nuclear bomb because of the scale of damage that it has been shown to cause.

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[156] Schneider, "The Emerging EMP Threat to the United States," 1.

[157] Ibid.

[158] Ibid.

[159] Department of State, "Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and Under Water," accessed September 17, 2014, http://www.state.gov/t/isn/4797.htm.

With the increased nuclear weapons proliferation as previously discussed, the risk of nuclear weapons and various delivery systems falling into the hands of a rogue state or non-state actor has increased. Unfortunately, the concept of nuclear deterrence is greatly diminished if a nation has to face the EMP threat from borderless non-state actor.

This fourth case study will look at SCADAs and show how these electronic devices are essentially the Achilles'' heel of modern critical infrastructure. The 2008 EMP Commission revealed that SCADAs, as part of the essential and ubiquitous technology used for automated monitoring and control systems, was vulnerable to EMP and cyber attacks. SCADAs are an enormous economic benefit because they can provide a level of efficiency, safety, and agility to various infrastructures that is impossible without automation.[160] These electronic control systems govern every aspect of data acquisition and control over a vast geographical expanse for various infrastructure systems. SCADAs themselves may differ from one industry or application to another. However, they all share certain commonalities and vulnerabilities.

The San Diego County Water Authority, and San Diego Gas and Electric companies discovered a vulnerability in their SCADAs in November 1999. Both of these companies experienced major malfunctions in their SCADA systems due to electromagnetic interference caused by a radar operating off of a ship roughly 25 miles offshore. The malfunctions caused SCADAs to fail in their ability to control critical valve openings and closings. Technicians were required to manually open and close various water and gas valves across a large geographical area to avert disaster. The San Diego County Water Authority later informed the Federal Communications Commission that

[160] Foster et al., *Commission to Assess Threat from EMP*, 1.

the disruption to their SCADAs from the ship's radar had the potential to cause "catastrophic failure"[161] within the aqueduct system to include "spilling vents at thousands of gallons per minute to aqueduct rupture with ensuing disruption of service, severe flooding, and related damage to private and public property."[162]

The supervisory control functions within SCADAs give these components the ability to actively control operations within a system. For example, if there is a critical component failure or accident within an infrastructure system, the SCADAs that monitor the system can automatically alert the appropriate authorities.[163] Additionally, SCADAs can make adjustments in order to compensate for failed components and prevent total system disruption or failure. Some examples of automated on-the-fly adjustments may include electrical load balancing, valve pressure adjustments, and executing computer commands to enforce pre-programmed safety protocols.[164] Physically, SCADAs resemble the typical hardware as seen in the average desktop computer. Cables connect to the SCADA to various sensors that allow the system to issue commands and control the electronic and mechanical devices in order to adjust system performance within a particular infrastructure subcomponent.[165]

SCADA systems, as an integral part of the various infrastructures, are by default distributed in remote environments in order to control systems in the absence of human

[161] Ibid., 2.

[162] Ibid.

[163] Ibid.

[164] Ibid., 3.

[165] Ibid., 2.

intervention. These systems are typically housed within metallic enclosures that serve to protect the components from the elements.[166] These metal housings provide minimal protection against electrostatic interference and are not designed to serve as a Faraday cage that would provide such protection. The cables that connect to the SCADA extend beyond the bounds of their respective housings are vulnerable to EMP, as the cables themselves can act as antennas that can propagate the energy from the pulse itself.[167] Figure 6 depicts an example of a SCADA controller that is fairly representative of these systems:

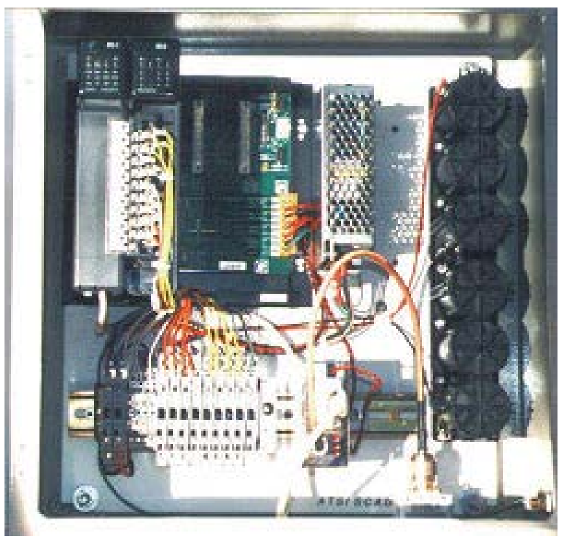

Figure 6. Typical Representation of SCADA Hardware

Source: Dr. John S. Foster, Jr. et al., *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack: Critical National Infrastructures* (McLean, VA: Electromagnetic Pulse (EMP) Commission, 2008), 2.

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[166] Ibid.

[167] Ibid., 5.

Testing of various types of SCADA were included in some of the previously mentioned EMP simulations and experiments. It is interesting to note that during an experiment that used relatively low electromagnetic stress levels, SCADA components would not necessary be physically damaged, but would instead have errors, lose calibration, or yield false readings.[168] Though the effects on SCADA and other subcomponents were not necessarily damaged or destroyed in all cases, the most vulnerable part of the system occurs within the control system's communications link. Systems linked via Ethernet and PC networking systems suffered extensive damage.[169]

The use of SCADAs are totally unavoidable at this time for the function of modern infrastructure and associated systems and subsystems. The benefits and efficiencies that stem from their usage are almost impossible to quantify. Nearly every aspect of modern society is dependent on the ability for these behind-the-scenes devices to provide essential services and to keep modern society functioning.[170] EMP poses an immense risk to their ability to provide these essential services. The vulnerability of SCADAs to EMP damage is arguably the Achilles' heel to the ability for any modern nation to provide essential services to its people.

The final case study will discuss the U.S.-Canada black out of 2003.[171] In this example, the vulnerability of the electrical power grid to minor damage has shown to cause regional disruption to power. Since this event revealed that even minor damage can

[168] Ibid., 39.

[169] Ibid.

[170] Ibid., 2-3.

[171] Diaz et al., "Final Report 2003 U.S.-Canada Blackout," 1.

be the cause of such widespread disruption, both the U.S. and Canadian governments commissioned a joint study to identify further vulnerabilities.[172] This government sponsored study also resulted in changes in policies and procedures designed to mitigate similar events from occurring in the future. These changes also serve to bolster the resilience of the electrical power grid and serve to reduce some of the vulnerabilities to EMP.

The U.S.-Canada Power System Outage Task Force was established as a joint endeavor between the two respective governments in order to ascertain the cause of the August 14, 2003 blackout that afflicted multiple U.S. states and Canadian provinces. The task force produced an very detailed analysis of what caused the system failure. In their 238 page report, *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*, six direct causes and contributing factors were identified.[173] These included elements such as failure to maintain adequate reactive power support, operating within safe limits, vegetation management, training shortfalls, and communications procedures within adjacent systems and to the regional levels during systems failure.[174] It is interesting to note that of the six causes listed, vegetation management was listed as one of the contributing factors. In essence, an overgrown tree within the transmission line right-of-way in southern Ohio was touching the high voltage transmission lines and caused cascading power failure across the northeastern U.S. and

[172] Ibid.

[173] Ibid., 139.

[174] Ibid., 139-140.

Ontario, Canada.[175] Though by itself, this would not have been sufficient to cause regional power disruption because electrical power is designed to react and redistribute power as needed, it was the proverbial straw that broke the camel's back.

Prior to the Ohio tree incident, there were unplanned power outages already occurring in Indiana and Ohio. One factor was a computer systems malfunction coupled with procedural violations at Midwest Independent System Operator (MISO), who is the grid power reliability coordinator for FirstEnergy, who provides power to northern Ohio.[176] In particular, while MISO was experiencing potential computer systems issues, they failed to notify other reliability coordinators as required by NERC policy requirements. Secondly, MISO was also violating NERC policy by using non-real-time data to support real-time operations. Thirdly, MISO lacked procedures and guidelines governing the coordination efforts needed to maintain system reliability with adjacent power reliability coordinators.[177]

Also prior to the Ohio tree incident, a power failure at the Eastlake Unit 5 power-generating unit occurred. This particular unit was a critical source of real and reactive power for the Cleveland-Akron areas in northern Ohio, and did not have sufficient capacity to provide reactive power, which led to the unit's protection subsystem to ultimately shut down the unit. The tipping point that ultimately led to cascading systems failure, was a tree touching high voltage power lines in southern Ohio, run by the Dayton Power and Light control area, that caused a localized power outage.

[175] Ibid., 27.

[176] Ibid., 12.

[177] Ibid., 20.

What is significant about this seemingly small disruption, is that reactive power was being rerouted to compensate for the Dayton Power and Light control area. In particular, MISO operators were not monitoring this particular outage because it was outside of their footprint and were completely unaware that the southern Ohio portion was out of service. MISO operators' failure to monitor this service disruption, coupled with their computer issues, led to a data mismatch in their power state estimators which resulted in unusable data later in the day, as other systems began to fail within the FirstEnergy area.[178]

This series of events in Ohio triggered a cascading power failure across the northeastern U.S. and Ontario, Canada as frequency, voltage, and power swings started in an attempt to rebalance and redistribute power. Once this back and forth power flow across multiple neighboring states started, the grid was not able to recover and the result was total system failure.[179] This incident caused an estimated 50-million people to be without power. In the United States, cost was estimated to be between $4 and $10 billion. Cost estimates in Canada were in excess of $2 billion. Parts of the U.S. were also without power for up to four days, while parts of Ontario suffered rolling blackouts for over a week.[180]

This particular case study clearly illustrates the fragile nature of the North American electrical power grid. Minor damage, when coupled with other seemingly unrelated events, has exposed critical vulnerabilities to the overall electrical power grid

[178] Ibid., 27.

[179] Ibid., 29-30.

[180] Ibid., 1.

which can ultimately lead to wide-spread and in some cases, persistent systems failure. The governments of the U.S. and Canada have implemented many of the recommended policies and procedures in the report in the form of legislation and reorganization reforms to better tackle the shortfalls. What is also clearly illustrated is that an EMP attack could cause similar results and disrupt power, but due to the potential geographical magnitude of the damage, recovery efforts to restore power would be severely hampered. U.S. Government estimates for recovery time in the event of an EMP attack would likely range from months to years, instead of from days to weeks.[181]

[181] Foster et al., *Electromagnetic Pulse (EMP) Attack. Volume 1*, 19.

CHAPTER 3

RESEARCH METHODOLOGY

The research methodology used in this thesis was a review of documentation and pre-existing research data. The primary source of the documentation will be derived from official government documents and publically available research data, thus no new data will be generated or collected. Government documents from the DOD, DHS, NASA, the National Academy of Sciences, as well as from other credible sources will be used in this research. The major drawback to this methodology is the inherent lack of flexibility in attaining or generating new data or deriving facts from experimentation. However, the topic of this thesis does not lend itself to generating new data, and experimentation is well beyond the scope of this research paper.

The primary purpose of this research is to determine if there is a correlation between national policy and strategy to the practical application of consequence management of the effects of an EMP attack. Additionally, there are second and third order effects that must be considered. The research methodology will establish an understanding of EMP effects, the policies and strategies at a national level, and the doctrine and methodologies of the DOD and the DHS at the lowest level. This will establish the necessary framework to better understand the recommended solutions to the problem.

Research of historical data from EMP events, both naturally occurring and man-made, will establish a baseline understanding and alleviate any misconceptions of the nature of what EMP really is, as opposed to what is commonly depicted in science fiction and pop culture books and movies.[182] An examination of naturally occurring EMP phenomena from CME, namely Carrington Event of 1859, the great geomagnetic storm of 1921, the 1989 Quebec Blackout Storm, and the U.S.-Canada blackout of August 2003 will serve to highlight the frequency of occurrence as well as the severity of these events.

Additionally, this research will analyze national policies in three distinct tiers. At the strategic level, a look at Presidential Policy Directives and top level DOD and DHS policies will establish to what degree of emphasis is placed on defense measures designed to protect and mitigate against EMP effects. In addition to examining official policy documents, a look at nuclear non-proliferation strategies employed by the U.S. against hostile states such as Iran and North Korea as it pertains to the employment of nuclear capabilities as an EMP device. Moreover, this research will ascertain what top level resources are to be allocated for the purposes of consequence management and disaster relief, should an EMP event result in a crippling of critical infrastructure, namely the national electrical power grids.

Furthermore, research into the "middle tier," or operational level, in terms of policy and practice will identify the level of emphasis placed on the larger scale training and coordination between agencies specifically designed for consequence management and disaster relief. At the operational level, this research will delve into the working relationships and collaborative efforts of the DOD and DHS subordinate activities. Specifically, an examination of how the U.S. Army and FEMA plans to work together to respond to large-scale crisis caused by EMP. By studying the policies and coordinated

[182] Electromagnetic Pulse weapons were used in several television series such as Star Trek: Deep Space 9, Dark Angel, Jericho, Stargate SG-1, Knight Rider, and Fallen Skies to name a few.

training strategies between the U.S. Army and FEMA, this will establish the necessary framework for facilitate further analysis into effectiveness of the tactical level of operations.

Research into policies, training, and allocated resources at the “lowest tier,” or tactical level, will help to identify the level of coordination between specific capabilities within the U.S. Army and within FEMA. Study of the U.S. Army will provide an insight into the training and capabilities it would bring to bear on large scale disaster relief and consequence management as part of its Defense Support of Civil Authorities (DSCA) mission since it has the lion’s share of personnel resources within the DOD. If the scale of disaster relief is sufficiently large enough, the active, reserve, and guard components of the U.S. Army will likely be called to augment FEMA at this level.

In summary, my research will analyze the most likely effects of an EMP attack on the U.S. power grid and attempt to determine if the national security strategy to defend against EMP attack will provide a sufficient response. Additionally, analysis of these strategies will attempt to determine if this response is also sufficient to address the possible aftermath of such an attack and protect the U.S. population. Recent government research and experiments into this topic has been conducted on a rather limited scale and as such, the results are not comprehensive. EMP has been shown to be destructive to electrical components during nuclear tests conducted in the 1960s. However, the conditions that exist today are much different in terms of the widespread use of sensitive electronics and microchips that did not exist during those tests. EMP effects also occur as a natural byproduct of CME from the Sun interacting with Earth’s upper atmosphere. The effects are well documented showing that it has disrupted electronics and the power grid resulting in extensive blackouts. The data from these effects will be further analyzed to determine the overall resilience of the power grid. Specifically, an analysis of various case studies will be used to deduce the potential effects of an EMP attack and be used illustrate the second and third order effects of widespread power disruption. The case studies will be based on historical, experimental, and modelling data to determine as realistically as possible if U.S. national strategy policies and practices are sufficient to defend against EMP and its associated after effects.

CHAPTER 4

ANALYSIS

> Engage people with what they expect; it is what they are able to discern and confirms their projections. It settles them into predictable patterns of response, occupying their minds while you wait for the extraordinary moment—that which they cannot anticipate.[183]
>
> — Sun Tzu, *The Art of War*

Case Study Context and Overview

The five case studies described at the end of chapter 2 are unique in terms of their root causes and scope. However, they all share commonalities related large-scale electrical infrastructure failure and the resultant unpredictable nature of second and third order effects. Advances in modern electronics have made many of these systems more efficient in terms of overall cost savings as well as in the capability to provide electrical power throughout the North American continent. Within the context of the electrical infrastructure's resilience against the effects of a HEMP attack, all of the case studies described herein have shown potential for an unprecedented magnitude of systems failures.

Though the financial costs of widespread power failure are significant in terms of loss of commerce and necessary repair expenditures, the effects that follow often prove to be much more costly. Electrical power used for climate control is often times most vulnerable to disruption during times when temperatures are more extreme. There are cases every year, notably during the colder months, where ice storms will cause critical

[183] Wikiquote, "Sun Tzu," April 26, 2014, accessed May 17, 2014, http://en.wikiquote.org/w/index.php?title=Sun_Tzu&oldid=1727861.

power lines to fail. Needless to say, it is during these times when people truly need power and other infrastructures to provide adequate heating to their homes and places of work.

The human dimension has also revealed itself to be unpredictable in times of crisis. Though is it common to see communities come together and provide mutual support to one another during such times, there are occasions that show that the opposite also holds true. The 1977 New York City blackout case study serves to highlight one such example. The combination of social uneasiness due to financial hardship and unemployment only needs a trigger, such as a citywide power failure, to incite an already tense social atmosphere that ultimately led to widespread violence.

Finally, the ability to mitigate the vulnerabilities to the electrical power infrastructure are extremely challenging when put in the context of a deliberate HEMP attack. The damage and ability to facilitate repairs will undoubtedly be more difficult when compared to the generally isolated damage and disruption caused by severe weather. During an extended power outage, the infrastructure requirements of a densely populated urban area to function adequately will prove to be the most difficult to manage in terms of providing essential services and preserving rule of law.

Cross-Case Theme Analysis

Linking the five case studies across their common threads will serve as the basis for analysis in regard how they will likely related to each other following a HEMP attack that results in electrical infrastructure damage. Based on the nuclear testing case study, it remains clear that HEMP will cause damage to electrical systems across a vast geographical area. Additionally, the vulnerabilities of the electrical grid infrastructure as revealed by the 2003 U.S.-Canada blackout has shown that even minor damage to certain key components in certain key locations are enough to cause cascading systems failures. Finally, by further linking the human dimension to an already difficult scenario, the potential for societal breakdown becomes very real.

As previously mentioned, a HEMP attack has the potential to cause enough damage to infrastructure to the point where repairs would likely take months or even years before power can be restored.[184] More importantly, this particular estimate comes from the studies and research commissioned by the U.S. Congress. Though this may cause the potential for panic, awareness of critical systems vulnerabilities is the first step towards addressing those shortfalls. The recommended actions to harden the infrastructure against the damaging effects of EMP would be extremely costly and time consuming, and as such, are not likely to be popular topics during fiscally constrained times.

The elapsed timeline of both the initial 2004 EMP threat assessment[185] and the subsequent report in 2008[186] to Congress are significant. It has been over 10 years since the initial report, with little change to the overall premise of the 2008 final report. It is notable that the data and analysis in both reports have enjoyed the test of time for which subsequent research may have resulted in a debunking of the assessed EMP threat. Even if the EMP threat was only partially disputed, there has been no additional research that has yielded significantly reduced estimates for when grid power would be restored.

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[184] Foster et al., *Electromagnetic Pulse (EMP) Attack. Volume 1*, 19.

[185] Ibid.

[186] Foster et al., *Commission to Assess Threat from EMP.*

Power failures caused by EMP are expected to be very lengthy as determined by government EMP threat assessment estimates. Other infrastructures such as water supply and distribution would be expected to be disrupted by the mere absence of electrical power from the grid. However, EMP would also cause damage to these other infrastructures directly as they all rely on SCADAs in order to function. The SCADA vulnerability case study clearly describes the susceptibility to damage these systems pose to any other subsystem that is connected to them.

Failures in the operation of subsystems within a larger framework is in turn highlighted by the 2003 U.S.-Canada blackout case study,[187] which showed the potential for tremendous and far reaching consequences. The inherent design of the electrical power infrastructure incorporates the capability for redundancy and adaptability in how power is redistributed and monitored to compensate for a failure to part of its network. However, this system is not without its limitations. This case study revealed that once a certain threshold is exceeded in terms of its ability to make adjustments to regional power distribution, the potential for cascading failures is a side effect with the potential for extensive ramifications.

The 2003 U.S.-Canada case study can also serve as an example of the potential effects of EMP, even if the damage turned out to be limited in its geographic coverage.[188] As power distribution attempts to compensate for a loss of power in one region by rebalancing the load in other areas, the potential for the system as a whole to experience cascading failures still exists eleven years later, despite our current understanding of this

[187] Diaz et al., “Final Report 2003 U.S.-Canada Blackout.”

[188] Ibid.

vulnerability. Though measures, such as ensuring the regional interconnections are electrically separated, have been made to increase overall power grid resiliency, these adjacent systems still lack frequency independence from each other. Ultimately, a strong enough EMP could trigger regional level cascading failures across an extensive geographical area.[189]

In addition to the various infrastructure failures that could follow an EMP attack, the disruption of food distribution becomes an issue that will certainly cause unrest in the local population. As food and water supplies become scarce in the days following an EMP attack, people will become more desperate as time moves on. The likelihood of rioting, looting, and civil unrest will likely overwhelm the capacity of law enforcement, especially in densely populated areas. Additionally, with the subsequent water distribution infrastructure failures, fires within cities will likely burn unchecked as water pressure to fire hydrants will also be disrupted.

The 1977 New York City blackout case study[190] serves to provide a glimpse at the potential "tip of the iceberg" in terms of problems that could occur within cities during periods of prolonged power disruption. Some problems would include disruption of sanitation within populated areas as sewers and water distribution due to loss of power to the pumps necessary for the proper function of these systems. In addition to heightened tensions within the general population, the increased likelihood of disease and gastrointestinal illnesses would be magnified while water and sewage systems remain

[189] Foster et al., *Commission to Assess Threat from EMP*, 25.

[190] Long, "July 13, 1977: Massive Blackout Plunges New York Into Rioting."

inoperable. The longer the disruption in power, as would be the case following an EMP attack, the greater the magnitude of these problems within urban areas.

The case study describing the 2012 power failures which coincided with a heat wave, illustrates the impacts a lack of electrical power has on climate control.[191] Additionally, segments of the population that have underlying medical conditions that make them more susceptible to extremes in temperature, are most at risk. Even during a relatively short-term disruption to electrical power can prove to be fatal to those most vulnerable. Long-term power disruption of services, as would be expected following an EMP attack, would undoubtedly exacerbate the number casualties within the first several days of following such an attack.

By stacking the effects from all five case studies, the threat that a HEMP attack poses would in all likelihood, vastly overwhelm any kind of relief efforts by any and all levels of government. The aftermath of this worst-case scenario could potentially cripple a superpower, even one as powerful as the United States. EMP has the ability to serve as the great equalizer for nations or non-state actors that are militarily inferior to those they would oppose.

Assertions and Generalizations

It can be said that terrorist attacks can be prevented if given preparation and sufficient resources on the part of a nation. However, the adequate or appropriate level of protection against any potential attacks is a source of great debate. Budgetary priorities, resource availability or constraints, training of personnel, and any multitude of other

[191] Centers for Disease Control and Prevention, “Heat-Related Deaths.”

factors can serve to either enhance or weaken the ability of a nation to defend itself. It is important to understand that the enemy also has a vote when it comes to these kinds of scenarios.

Large-scale disasters, notably the hurricanes that have occurred in recent history, have had the beneficial effect of bringing to light some of the shortfalls within the U.S. disaster response framework. The creation of the Department of Homeland Security following the aftermath of the September 11, 2001 terrorist attacks has served to streamline many of the disaster response functions within the government. Two major improvements to the system included the implementation of NIPP and NIMS. However, like all major changes and organizational overhauls, there are growing pains that can take many years to work out.

All disasters, EMP or otherwise, pose tremendous challenges. The greatest of these challenges lies within the unpredictability of the human dimension. Author James W. Rawles gives the following example:

> In my lectures on survival topics I often mention that there is just a thin veneer of civilization on our society. What is underneath is not pretty, and it does not take much to peel away that veneer. You take your average urbanite or suburbanite and get him excessively cold, wet, tired, hungry, and/or thirsty and take away his television, beer, drugs, and other pacifiers, and you will soon see the savage within. It is like peeling the skin off an onion—remove a couple of layers and it gets very smelly.[192]

Our modern society is relatively peaceful, especially in Western countries. All the comforts that modern society brings to the table serve to enhance the overall wellbeing of the general public. However, in the absence of these comforts, humans can be expected to

[192] James Wesley Rawles, *How to Survive the End of the World as we Know It: Tactics, Techniques, and Technologies for Uncertain Times* (New York, NY: Penguin Books, 2009), 6-7.

exhibit survival instincts and behaviors that under normal circumstances, would not likely surface.

Despite the successful response demonstrated by NORAD to address the 9/11 terrorist attacks,[193] there is no precedent that can measure the necessary response for an EMP attack. Exercises such as Global Guardian and Vigilant Guardian are an important method in which to test procedures and coordination efforts between the military and other government agencies. The level of consequence management response to a nuclear or EMP attack remains untested. Unfortunately, U.S. policies and doctrines designed to address these response capabilities can only be applied to an EMP attack scenario based on theory, not practice. Government response is likely to be severely lacking in its ability to adequately respond to the needs of the general population. The people responsible for consequence management at the tactical level also have families to attend to and protect, especially in a very likely event that law enforcement capabilities become overwhelmed and severely degraded. My analysis of the various tiers of policy and doctrine indicates that the response level likely be the most effective, is that at the lowest level, namely individual and family groups that work together. Following FEMA's published individual and family preparedness guidelines would likely result in more lives saved than any other large agency response. Such a large-scale response may never materialize due to the widespread crippling effects that an EMP attack would potentially pose.

[193] Kean et al., *The 9/11 Commission Report*, 458.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

An EMP attack against the American homeland remains one of the most dangerous threats to public safety and the American way of life. The impact of EMP against U.S. CI/KR would be crippling. Regionally extensive disruptions to electrical power, communications, water distribution, food distribution, commerce, and travel would not only have immeasurable economic costs, but also cost countless lives. U.S. policies and practices are well developed, and the DOD and DHS are well trained for disaster consequence management. However, the sheer scale of damage and disruption that the EMP threat poses is beyond any scenario the U.S. has ever faced.

It remains unclear if the U.S. would be sufficiently capable of providing the level of response needed to manage the consequences of an EMP attack. In all likelihood, the required response would be woefully inadequate. The ubiquitous reliance upon modern technology to conduct a seemingly basic function such as communication would be an extremely difficult hurdle to overcome if the overall capability was severely degraded. Disabled communications alone would make coordinated efforts between entities reacting to such an attack enormously more problematic. Other factors such as severe degradation to the transportation, water distribution, and fuel distribution infrastructures would serve to further complicate and severely delay recovery efforts.

Perhaps even more dangerous to the overall welfare of the homeland following the aftermath of an EMP attack, are host of secondary and tertiary effects that surface after widespread damage and disruption to CI/KR. Prolonged disruption to electrical power will cause transportation to grind to a halt and prevent food distribution. Additionally, water and fuel distribution systems would cause sanitation systems to eventually fail leading to possible disease outbreaks, especially in more densely populated areas. Law enforcement capabilities will also be overwhelmed as a break down in law and order ensues as the general population experiences great stress due to the unavailability of basic life sustaining goods and services.

With the impact that EMP could have on the homeland, significant burden is placed upon political leaders to ensure that an emphasis on policies, legislation, and resources are allocated to hardening the CI/KR. The DOD and DHS would also be expected to lead in current efforts to train and equip the right personnel to handle the requisite level of consequence management capabilities. Likewise, efforts by FEMA to encourage and facilitate individual preparedness are a practice that has proven to be effective in enabling relief efforts following large-scale disasters.[194] EMP consequence management will undoubtedly pose significant challenges. FEMA currently offers the best approach to recovering from such a disaster, by pushing awareness, training, and preparation across all aspects the government and all the way down to private citizen.[195]

Recommendations

Reaching the goal of having a robust EMP consequence management capability would need to include three key areas. Firstly, emphasis by the political leadership needs to take place. Secondly, increasing resilience of CI/KR needs to be prioritized by all key

[194] Federal Emergency Management Agency, "Plan, Prepare and Mitigate."

[195] FEMA/Ready.gov, "Prepare, Plan, Stay Informed."

stakeholders. Thirdly, the expansion of training and preparedness efforts at all levels will bolster recovery efforts and reduce the strain on limited government resources.

An emphasis by political leadership towards reducing the inherent vulnerabilities of the electrical power grid needs to go beyond lip service. Actions need to take place to include the passing of important legislation in a timely manner. The CIPA[196], GRID Act[197], and SHIELD Act[198] were all introduced in 2013, but have not progressed beyond their initial introduction to the legislative houses in excess of a year. The potential devastation that an EMP could have against the U.S. warrants a sense of urgency by our policy makers. Implementation of legislation would also be expected to take time, if any of these bills eventually becomes law. Though the existing pending legislation has the support of both of the primary political parties, it is essential that these laws do not become lost in the bureaucratic noise that is often perceived, and that these laws are passed in a timely fashion. Though these proposed laws are not all-inclusive to mitigate against EMP damage to CI/KR, they are undoubtedly a step in the right direction.

Bolstering the resilience of CI/KR is of paramount importance in an effort to mitigate the damaging effects that EMP could potentially cause. Study of the 2003 U.S.-Canada blackout revealed the vulnerabilities of the electrical power grid that resulted in

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[196] U.S. Congress, *Critical Infrastructure Protection Act*, H. Res. 3410, 113th Cong., 1st sess., October 30, 2013.

[197] U.S. Congress, *Grid Reliability and Infrastructure Defense Act*, S. Res. 2158, 113th Cong., 2nd sess., March 26, 2013.

[198] U.S. Congress, *Secure High-voltage Infrastructure for Electricity from Lethal Damage Act*, H. Res. 2417, 113th Cong., 1st sess., June 18, 2013.

systems to experience cascading failures.[199] This scenario provides valuable insight into the system failures that would likely occur following an EMP attack. To enforce practices to improve the resiliency of the electrical power grid, organizational oversight by the NERC, was established through legislation, in response to the 1965 Northeast Power Failure that spanned a large geographical area.[200] The NERC was granted the legal authority to impose fines upon power companies that failed to meet regulatory requirements.[201] Though the threat is understood and fairly well documented, the economic cost towards hardening CI/KR against EMP remains a factor that key stakeholders seem resistant to tackling at this time.

A recommendation to bolster power grid resiliency, is to further subdivide the NERC interconnections. Instead of only having three massive power grids, a host of smaller grids needs to be established. Within this framework, the smaller grids will need to be designed in such a way that they are not only electrically separated, but also separated in terms of electrical frequency. This will prevent the adjacent grids to collapse if there is significant damage or strain on one particular grid. This design would likely be more expensive, but in light of the potential for disastrous cascading power grid failures, it will prove to be much more robust from a homeland security perspective.

Thirdly, the efforts made by DOD and DHS need to be continued. Many of the practices conducted by both of these departmental agencies have proven to be quite effective in disaster consequence management. The best practices learned from the speed

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[199] Diaz et al., “Final Report 2003 U.S.-Canada Blackout.”

[200] Foster et al., *Commission to Assess Threat from EMP*, 20.

[201] Whatis.com, “North American Electric Reliability Corporation (NERC).”

and ability of NORAD to react to the 9/11 terrorist attacks[202] should be capitalized on and further expanded towards EMP consequence management. Particularly, the military staff that was available to successfully react to the 9/11 attacks, needs to be a construct that remains in place beyond the confines of large scale annual training exercises such as Global Guardian and Vigilant Guardian. The success of the DOD, DHS, and partner agencies requires the support of our policy makers. Adequate resourcing, manning, training, equipping, and financing are all elements crucial to the success and expansion of the current capabilities needed to react to and recover from an EMP attack.

In summary, in order to achieve a robust EMP consequence management response capability, it is essential that the political leadership places EMP consequence management as one of their key priorities. Prioritization directly lends itself to the enforcement of regulations and standards that are designed to bolster the resilience of CI/KR and reduce vulnerabilities to the possible effects of EMP. Finally, the efforts being made towards building awareness and disaster preparedness for all segments of American society cannot be overstated. The ability for the U.S. to recover from an EMP attack lies in the aggregate successes of all three of these elements.

Recommended Topics for Further Study

Further research into related HEMP consequence management topics could include societal concerns, policy development, private sector integration, and civilian-military cooperative efforts. Though the threat from HEMP attack is the primary focus of this paper, any of the aforementioned research topics could be valuable in addressing

[202] Kean et al., *The 9/11 Commission Report*, 458.

other disaster scenarios. Further study into electrical power grid vulnerabilities, maintenance of the rule of law, and the military's DSCA mission would be valuable from a homeland security perspective. In any large-scale disaster or concurrent series of disasters, these topics share common concerns for disaster relief and consequence management planners.

Research into societal concerns could include topics such as culture, demographics, socioeconomics, and regional practices, and what role, if any, they might have in consequence management. Law enforcement requirements and social reaction to a disaster of significant magnitude may vary from region to region. These subtopics can be analyzed to see if there are common trends or specific needs a particular population may need that has to be addressed by disaster relief agencies. Though FEMA is subdivided into regional areas of responsibility, the areas themselves are too broad for a focused analysis on the complex nature of societal concerns during a disaster.

Research into policy development as it relates to addressing large-scale disasters could potentially be useful for policy makers and budget planners. Additionally, a detailed study of policy development could have valuable application towards disaster exercise planning. Subsequently, this could help bolster the realism and value of disaster training exercises, and ensure that appropriate resourcing and funding also take place. The behind the scenes efforts of policy developers often pays dividends in terms of cost savings, as well as the usefulness of training exercises that may stem from such policies.

Private sector integration in disaster consequence management is a topic of study that could prove to be valuable for the long-term. For example, better understanding the motivations and needs of various private sector industries can help in cooperative efforts that potentially lead to more robust infrastructure and safeguards. Particularly, potential industry vulnerabilities within the power grid infrastructure lies in the availability, and location of manufacture, of large electrical infrastructure components such as transformers and circuits. Many of these components are not manufactured in the United States and must be shipped from overseas locations such as Germany. Another vulnerability is that many of the larger high-voltage components are not stocked, meaning that the parts themselves need to be manufactured as needed. The integration of the private sector plays a pivotal role in disaster mitigation. Additionally, study into this topic can prove to enhance ongoing efforts in the mitigation of future large-scale blackouts.

Lastly, further study in civilian-military cooperative efforts can prove to be useful. By studying historical examples and how they coincide with the policies that govern current practices, shortfalls as well as best practices can be identified. This should lend itself to more streamlined processes that ultimately lead to more lives saved during a disaster. The military's DSCA mission to support disaster relief efforts is continually undergoing refinement as real world lessons are incorporated into military doctrine. Additionally, if this research leads to increased levels of efficiency between civilian-military consequence management and mitigation efforts, taxpayers may expect to see significant cost savings.

In conclusion, further study into consequence management topics that include societal concerns, policy development, private sector integration, and civilian-military cooperative efforts, will likely prove to be beneficial. Policy makers and disaster consequence management planners should be able to integrate many of the lessons and deductions from such research and enhance existing disaster relief policies and practices. Study into electrical power grid vulnerabilities and the maintenance of the rule of law following a disaster, specifically as it pertains to the use of military forces is a topic worth further analysis. Particularly within the United States, there are legal and cultural considerations surrounding the employment of military forces on homeland, even for disaster relief and consequence management, regardless of the scale.

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