Summer 2017

Midnight in America: Nuclear Electromagnetic Pulse and the 21st Century Threat to the United States

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MIDNIGHT IN AMERICA: NUCLEAR ELECTROMAGNETIC PULSE AND THE 21st CENTURY THREAT TO THE UNITED STATES

A Masters Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Defense and Strategic Studies

By

Angela E. Weaver

May 2017

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Defense and Strategic Studies

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ABSTRACT

The electromagnetic pulse (EMP) effects produced by the detonation of a nuclear weapon at high altitude are capable of causing widespread destruction in the U.S. homeland with few to no immediate casualties. The threat of nuclear EMP attack against the United States was recognized as probable during the Cold War but as time passed, the threat lost consciousness among U.S. policy makers as other issues and threats rose to the forefront. Simultaneously, the United States military and civilian society grew increasingly reliant upon emerging electronic systems and capabilities while adversary nations and rogue states rapidly pursued nuclear weapons capabilities. Today, the United States, as one of the most highly developed nations on the globe, is reliant upon electronic systems for almost every aspect of life, from communications to economics and security. As such, the United States is highly vulnerable to attacks that affect these cornerstones of U.S. society and global presence. The threat of a nuclear EMP attack against the United States today and in the future is not only an effective option for both states and non-state actors, it is an attractive one. Adversaries could derive great value from an attack that cripples the U.S. ability to function at even the most basic levels. The threat of EMP attack is more prescient in today's modern warfare environment than ever before. As such, the United States' approach to nuclear deterrence and escalation control must evolve to fully encompass the threat of nuclear EMP by both state and non-state actors.

KEYWORDS: nuclear weapon, electromagnetic pulse, deterrence, defense policy, terrorism, United States, national security, threat

This abstract is approved as to form and content

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Professor David Trachtenberg
Chairperson, Advisory Committee
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ACKNOWLEDGEMENTS

I would like to thank the following people for their support during the course of my graduate studies:

My wonderful family, for their constant support and encouragement in every area of life.

My better half, for his support and enduring belief in my ability to be the best version of myself.

My dear friends, for their understanding and flexibility throughout the last two years.

And finally my professors and colleagues, for their willingness to debate me, listen to my theories and challenge me at every step.

I dedicate this thesis to the generations of civil servants who have come before me that worked tirelessly in pursuit of a greater security and prosperity for the United States and its citizens.

"The optimist thinks this is the best of all possible worlds. The pessimist fears it is true."
J. Robert Oppenheimer

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The end of the Cold War marked, for many, an end to the prominence of nuclear weapons. While Russia and the United States kept large numbers in their arsenals, the focus on nuclear weapons shifted from buildup to reduction and the role of nuclear weapons in U.S. national security strategy was greatly reduced. The United States largely breathed a sigh of relief and shifted focus to domestic issues, other regions of the globe such as Asia and, following September 11, 2001, long-term regional conflicts. Simultaneously, proliferation quietly continued in states across the globe. China built up its nuclear capabilities, Iran and North Korea further pursued nuclear weapons programs of their own, India and Pakistan competed in the nuclear realm and Russia continued to modernize and implement nuclear deterrence strategies for a multi-polar world. Terrorist organizations like al Qaeda stated their intentions to gain access to weapons of mass destruction (WMD) and the Islamic State in Iraq and Syria (ISIS) grew in strength, number and territory, also stating intentions to use WMD if successfully acquired. As the multi-polarity and variety of threats grew, nuclear weapons largely became, from a U.S. point of view, a weapon of a bygone era with limited scope and purpose. For other states and non-state actors, however, nuclear weapons remained the pinnacle of military achievement, a guarantor of safety and security in a world dominated by conventionally superior powers like the United States.

As the global security environment grew increasingly complicated, the technology environment blossomed. Electronic systems, internet connectivity, global positioning systems (GPS), energy and communications technology improved by leaps and bounds. The United States became increasingly reliant upon electronic systems for everything

from personal communication to banking to commercial travel to healthcare. Throughout the 1970's, the U.S. military executed the second offset strategy, investing in the technological advancements that would provide the military with capabilities like extended-range precision guided munitions, stealth aircraft and advanced C4ISR[1], all of which enabled the strategies of the United States throughout the Cold War and post-Cold War eras. Today, 99 percent of the electricity U.S. military bases use comes from the civilian electrical grid[2]. Advanced U.S. military systems depend on electronic systems' interaction with satellites to target, communicate and travel. These capabilities make the United States a leader in both commercial and military technology, however they also create a significant vulnerability. If the United States experienced widespread electronic disruption or failure, the effects would be felt in every aspect of civilian and military life. A catastrophic failure of electronic systems would impact the ability of emergency services to respond to crisis, running water and access to food over the long term would be threatened, communication made extremely difficult, if not impossible in the immediate aftermath, and the ability of the U.S. military to respond in any meaningful way, both at home and abroad, severely hampered. While this seems in many ways like science fiction, the capability exists to cripple the United States' ability to function at even the most basic level – and it has existed since the first nuclear weapon was detonated, more than 70 years ago.

The use of electromagnetic pulse (EMP) as a weapon is a long-held concept of warfare, especially among U.S. adversaries who have held the capability for decades. During the Cold War, the main concern about EMP emanated from the Soviet strategy to cripple or extinguish the ability of the United States to retaliate before a second strike on the U.S.

homeland could be initiated, in the form of a high-altitude nuclear detonation over the United States resulting in widespread EMP. However, this notion was largely rejected as a strategy because many theorists of nuclear deterrence believed that the risk was not worth the reward for the Soviet Union. If EMP worked as demonstrated in the nuclear tests of the 1960's, it was a suicide mission. Based on the deterrence strategy of the time, the United States would undoubtedly respond in kind, all but guaranteeing an overwhelming nuclear attack on Soviet territory. The stakes during the Cold War were far too high and both sides relied so heavily on the theory of mutually assured destruction that the idea of using a nuclear weapon for gaining the upper hand, however briefly, in what would ultimately be a nation-ending war was not plausible, nor attractive. Today, however, the world is very different. Nuclear weapons are possessed by nine states instead of two, all with varying interests and strategic goals and quite different views on the implementation of nuclear weapons as a tool of war in the 21st century. Additionally, rogue states and non-state actors are potentially capable of launching their own nuclear attacks if not now, then in the foreseeable future.

The risk and reward calculus has changed dramatically for U.S. adversaries who seek to achieve strategic effects against the United States, in turn altering the deterrence and escalation calculus. An adversary may choose to employ nuclear EMP in theater, rather than over the U.S. homeland, rendering U.S. forces abroad incapable of responding to regional or allied crises. The risk of a nuclear EMP attack against the United States remains unlikely in comparison to smaller scale terror attacks or other security events but the consequences of such an attack, if not prevented or deterred, would be catastrophic. Yet, while any employment of a nuclear weapon would be viewed by the United States as

extremely escalatory and would provoke a serious U.S. response, it is unclear that that response would be nuclear. The United States possesses the ability to hold at risk high value targets with capabilities other than nuclear weapons, options such as cyber, which very well may be considered proportional as a response. High-altitude nuclear detonations cause widespread electrical and infrastructure damage, but they rarely result in immediate human casualties. Nuclear EMP can also be difficult to attribute, much like large-scale cyber-attacks. These factors may very well complicate the U.S. response calculus.

This thesis examines the level of threat a nuclear EMP attack on the U.S. homeland or in theater represents in the 21st century modern warfare environment and analyzes the effect a threat of nuclear EMP has on deterrence and escalation. The first chapter provides an eagle eye view of the international security environment through the year 2040 to give context to the issue and remove nuclear EMP from its traditional Cold War boundaries. The second chapter identifies how the United States understands the conduct of modern warfare and establishes current U.S. deterrence and employment policy regarding nuclear weapons. The second chapter will also explore how key U.S. adversaries Russia and China are approaching modern warfare and nuclear deterrence in the 21st century and introduce how nuclear EMP complicates that environment. The third chapter quickly summarizes the history of nuclear EMP, describes the effects of an EMP attack versus the effects of a "traditional" employment of a nuclear weapon and introduces the historical views of the Soviet Union on EMP attacks during the Cold War. The fourth chapter is a case study of the 2003 Northeast blackout, analyzing the effects of the blackout on the civilian infrastructure and ability of the city to respond and recover.

The level of effect from the blackout is then compared to the estimated effect from nuclear EMP employment and identifies the implications for U.S. national security domestically and abroad. The fifth chapter explores the utility of nuclear EMP for both state and non-state actors and identifies the motivating factors for employing nuclear EMP. This chapter will also explore the strategy of employing nuclear EMP as part of a larger asymmetric warfare strategy. Finally, the sixth chapter explores the relationship between nuclear EMP and deterrence through analyzing how the employment of a nuclear weapon to produce EMP effects may change how the United States thinks about deterrence in the 21st century and identifying what policy options are available to the United States in defining a deterrence strategy specifically designed to prevent a nuclear EMP attack. Ultimately, the thesis will conclude with an identification of how likely it is that nuclear EMP is to be used in the modern warfare environment, evaluate the level of threat to the United States at home and abroad and identify recommendations for the United States to best address the threat as it exists in the 21st century.

DEFINITIONS

Nuclear Employment

There is an ongoing debate over the term nuclear "use" and, depending on the community, "use" can mean multiple things. For some, it means the detonation of a nuclear weapon in the context of a conflict. For others, it means the use of nuclear weapons as a political or deterrent tool. Former Defense Secretary James Schlesinger famously remarked, "We use nuclear weapons every day to deter our potential foes and provide reassurance to the allies to whom we offer protection"[3]. The author of this thesis tends to agree with Secretary Schlesinger, that nuclear weapons are indeed in use every day as guarantors of security. As such, "nuclear use" will not appear as a package term in this thesis so as to avoid confusion. Instead, "employment" will be used as a defining term for the detonation of a nuclear weapon in the context of active conflict or attack (testing excluded).

Electromagnetic Pulse

Electromagnetic pulse is a short burst of electromagnetic energy that, if strong enough, can disrupt or destroy electrical components but is not of direct harm to human beings. EMP can occur naturally, such as an effect of a strong geothermal storm or lightning strikes. There are weapons that exist solely for creating EMP effect, though those are not covered in this analysis. The EMP produced by a high-altitude nuclear detonation is much stronger and more widespread than any other manmade EMP occurrence, comparable only to a geothermal storm that directly affects Earth's atmosphere. High-altitude nuclear weapon detonations produce EMP in three waves as defined below[4]:

1) E1: An initial energy shockwave that is brief, about 1 microsecond. A pulse of energy, similar to extremely strong static electricity, traveling at

90% the speed of light, capable of destroying computers and other electronic devices in line of sight of the detonation.

2) E2: An intermediate pulse with a very similar effect as a lightning strike, unlikely to do damage to electronics or electrical systems already protected against surges from lightning strikes. However, most systems will be initially damaged from E1 and would likely experience additional damage if the protection systems went down in the initial E1 surge.

3) E3: A long-lasting magnetohydrodynamic (MHD) signal, a much slower pulse that travels through the magnetic field of the Earth, disrupting or in many cases, destroying power lines, electrical transformers and power plants. MHD occurs in two phases: Blast (distortion of the Earth's magnetic field lines by the expanding fireball) and Heave (heating and ionization of a patch of atmosphere directly below the detonation that rises and distorts the Earth's magnetic field)[5]. E3 only occurs in high yield detonations.

Asymmetric Warfare

Asymmetric warfare is typically defined as a conflict between actors that have significantly disparate levels of capability and as such, the conduct of warfare is unconventional. Asymmetric warfare can consist of guerilla tactics, information campaigns, cyber-attacks, WMD attacks, escalation of regional conflicts, conducted through engagement in proxy wars, or any combination of the aforementioned tactics. It is common that asymmetric warfare includes multiple unconventional tactics as part of an overall strategy. Attacks like 9/11 or the Sony hack by North Korea are often cited as examples of asymmetric warfare. This kind of warfare is becoming increasingly common in the 21st century as the relative military power of states becomes more and more disparate but access to lethal or disruptive technologies becomes easier. As is discussed further in this thesis, asymmetric warfare will become the norm for threat and conflict in the 21st century security environment. State actors will increasingly engage in asymmetric behavior as technologies proliferate and the security environment becomes more

crowded. Employment of devastating cyber-attacks, nuclear weapons or other WMD to create strategic effects in this environment are referred to as strategic asymmetric capabilities.

Rogue State

Rogue states are often ruled by autocratic regimes and generally hostile towards the United States. They often seek WMD capabilities, suppress or violate human rights and disrupt regional security. They can be sponsors or partners in terrorism as well. For the sake of this paper, when rogue states are mentioned or analyzed it is typically in reference to Iran or North Korea. Though these two countries are very different, they are the two most often labeled "rogue states". Iran's suppression of human rights, record of financing or otherwise state-sponsoring terrorist organizations and secret but diligent pursuit of nuclear weapons makes it an ideal, if nuanced, example of a rogue state. North Korea is more obviously a rogue state based on its isolation from the global order, violations of human rights and explicit and determined focus on developing a nuclear weapons program. These two rogue states will be focused upon heavily in this thesis as actors capable of and willing to employ nuclear EMP, especially in theater.

RESEARCH METHODOLOGY

The research for this thesis took several routes: technology, history and policy oriented. In order to best understand the motivations behind a state or non-state actor's decision to employ a nuclear weapon to achieve EMP effects, the author first needed to gain an understanding and appreciation for the effects of EMP and how they are produced. This consisted of reading through scientific journals and congressional testimony about electrical pulses (natural and man-made), solar storms and nuclear physics. Next, the author studied the 2003 Northeast blackout, not only to gain an understanding for the case study but to better understand the vulnerabilities inherent to electrical systems and the civilian infrastructure as a whole. Finally, in terms of technical research, the author had to understand what was needed to successfully employ a nuclear weapon capable of producing EMP effects. For example, it was essential to understand that high-altitude nuclear detonations, meaning at least 30km or more above the Earth's surface, are the most effective for producing EMP effects over a wide area. The technologies required to achieve a high-altitude detonation of a nuclear weapon are more intricate than a crude nuclear device and a missile.

For the greatest probability of success, the actor would likely acquire ballistic missile capabilities (short- or long-range and in some cases, intercontinental), a miniaturized nuclear weapon capable of being fitted to the ballistic missile and a physics package capable of withstanding the force of missile launch. However, the capabilities required for employment of nuclear EMP are not as complex as those needed for ground burst nuclear attack. For example, re-entry technology is not necessarily required. The complexity of the challenge was incredibly important to take into account when

contemplating the decision calculus of actors possibly looking to employ this capability against the United States or its forward-deployed forces in theater.

There is no credible basis to an analysis about a future threat without first understanding the historical basis from which the threat emerged. The methodology on historical context involved in-depth research about nuclear testing, specifically focusing on the Starfish Prime test, the first U.S. nuclear weapons test that exhibited EMP effects as far as 1,000 miles away. It was in this test that nuclear EMP began to emerge as a possible weapon in and of itself. The author also looked into Soviet nuclear weapons testing that exhibited EMP effects as well.

As time progressed, Congress and policy makers became increasingly concerned about the threat, causing Congress to establish the Commission to Assess the Threat to the United States from Electromagnetic Pulse Attack in 2001. The reports from this commission serve as the basis for the historical context of U.S. policy on the issue and as the cornerstone for establishing credibility about the level of threat facing the United States today and in the future. They also provide valuable information about the state of U.S. infrastructure and its ability to withstand (or not) the effects of nuclear EMP. The commission's report on U.S. critical infrastructure also serves the purpose of framing the arguments for adversarial use against the United States as it identifies key vulnerabilities and the effects of those vulnerabilities being realized through a devastating natural disaster, cyber or nuclear EMP attack. The Commission reports were especially eye-opening in terms of nuclear EMP as part of a larger asymmetric strategy. This becomes important in the analysis of deterrence and escalation decision making later on in the discussion.

Finally, the author needed to understand the policies enacted by the United States as well as potential adversaries on the subject of nuclear EMP, namely in the form of nuclear declaratory policies or national statements on the matter, many of which have been analyzed by U.S. experts. Russia and China are relatively clear about their broader nuclear policies though there is by nature some ambiguity involved in those as well. The challenge here was to try to identify the policies or doctrines, if such terms are even applicable, to rogue states or non-state actors. Terrorist organizations are by nature more declaratory than perhaps their capabilities can support but the history of their actions and stated goals give hints as to how they may choose to employ nuclear EMP – or perhaps why they would not. Rogue states are somewhat more formal in their statements but even in those instances, the sincerity of their claims can often be disputed. The secretive nature of rogue states and the actions they take make predictions of their future actions much more difficult to ascertain, though their intended goals are in some ways easier to identify than that of state actors. It was key to the analysis to make these distinctions as they become important when exploring the possible approaches to deterrence.

This paper will explore all sides to the question of the level of threat represented by nuclear EMP. The community debating this question has often been split into two camps: the side that believes that this threat is unrealistic or so unlikely that is hardly worth preparing to defend against, much less produce deterrence strategies designed specifically for the threat, and the side that believes the threat is quite real and without preparing for it or strategizing to prevent it, the United States is turning a blind eye to an existential threat. This paper aims to remain somewhere in the middle while exploring the virtues and misgivings of each side but will, in the end, come to a conclusion about the level of

threat nuclear EMP presents to the United States and its citizens. In order to do so, the author makes several assumptions upfront about the security environment, the role of the United States in the world and the role of nuclear weapons in U.S. defense strategy.

It is the assumption of the author that the security environment the United States will face through 2040 will be one of increasing complexity and instability. This theme will be further explored within the following sections but it is fundamental to understanding the approach to analysis found herein. If the world were in fact to become more peaceful, perhaps through the eradication of terrorism or a more balanced global order, the need for this analysis may not exist at all. However, it is in the belief of the author that the security environment is more likely to deteriorate in coming decades than stabilize that the motivation for exploring this subject in-depth is rooted.

Similarly, it is the assumption of the author that the United States will not shrink from the world stage but will continue to be a conventionally superior global actor with global interests. Globalization as a trend is assumed to continue due to communication and technological innovation and as a leading contributor to technological change, the United States is unlikely to become isolated, much less remain so. As such, U.S. interests and allied relationships will remain, meaning the United States will continue to be an actor both respected and feared. Threats from outside U.S. borders, it is assumed, will not dissipate but remain or grow.

Finally, the author assumes that nuclear weapons will continue to be a cornerstone of U.S. defense policy and strategy. No assumptions are made about the numbers of nuclear weapons the United States may retain or if the numbers will grow, only that the United States will not reduce to zero. The makeup of the nuclear arsenal – whether it

remains a triad or not – is also irrelevant to evaluating this threat. Though the force structure may matter to some aspects of formulating deterrence policy, it has little effect on the analysis of whether an actor will choose to use nuclear EMP against the United States or not. Retaliation with nuclear weapons is retaliation regardless of whether the weapon is launched from air, land or sea.

Throughout the research for this paper the author experienced several challenges. The arguments surrounding this threat are somewhat passionate and can feel very much like a conversation about science fiction at times. They also tend to be rather extreme in some cases – borderline fear mongering on one side and tacit dismissal on the other. While this is telling in terms of how split the community is on this issue, it also presented a challenge to finding sources that looked at the issue in a balanced and sober manner. The Congressional commission reports are the best sources in terms of a practical yet serious examination of the threat but they are, at this date, somewhat aged[6]. Old sources are a common problem when it comes to questions of nuclear weapons, though sources on deterrence and its practice are much more recent and modern.

With that in mind, the author looked to three main pools of sources: official government sources which assessed the threat and the technical and physical effects on the United States, the debates of the community on the validity of the threat one way or the other and both classic and modern approaches to nuclear deterrence, many of which do not make mention of nuclear EMP but are the best representation of current deterrence thinking and strategy. Through the combined analysis of these three pools of sources, the author was able to come to conclusions about both the level of threat and how it affects traditional approaches to nuclear deterrence and escalation.

CHAPTER 1: THE FUTURE SECURITY ENVIRONMENT TO 2040

The security environment is the driving force behind any threat to the United States and will shape U.S. force structure, posture and policy. The security environment through 2040 will exhibit several trends key to understanding the environment in which the threat of EMP may emanate: technological innovation, proliferation of WMD and shifts in regional power dynamics. Combined, these factors will challenging the primacy of the United States as a military actor on the global stage. As economic growth strengthens East Asia over time, the West may struggle to remain influential. This chapter will explore these trends in greater detail over the course of three periods of time[7] and identify the context for the threat of nuclear EMP and the actors who will likely acquire the capability to employ nuclear weapons with an intent of EMP effects.

2017-2025

The next eight years are likely to feature many of the same threats facing the United States today, though some will evolve. The threat of high end peer-to-peer competition or conflict with states such as Russia and China is likely to rise as both states continue to invest heavily in both traditional and hybrid warfare capabilities[8]. Investments in cyber and C4ISR capabilities and increasing numbers of unmanned and undersea platforms would complicate and already complex operating environment. The military modernization of Russian forces will likely enable continued open challenges to U.S. and NATO security, much like the activities undertaken in Crimea, Ukraine in 2013. Chinese economic growth will enable their ability to bolster military modernization[9] and provide a platform for continued buildup in the South China Sea, contributing to rising

regional tensions. The United States will likely continue to monitor the competitive balance of power in the Middle East, shaped by the conflicts in Syria and Afghanistan.

Unconventional warfare tactics and capabilities will begin to emerge more frequently[10] as rogue states and non-state actors continue to acquire, expand and improve nuclear, chemical and biological weapons programs, coordinated and sophisticated intelligence/espionage campaigns, mine and swarming capabilities and autonomous and deep learning machines. The importance of nuclear weapons in the defense strategies of the United States, Russia, China, and NATO is likely to rise as developing nuclear weapons programs in North Korea (and, potentially Iran) accelerate[11] and regional tensions grow. Health programs designed to defend against chemical and biological attacks will likely seek increased funding as a result of the increased threat of WMD employment by non-state actors, much like has been witnessed in Syria. Global insurgency by non-state and/or state-sponsored terror organizations, such as Al-Qaeda and ISIL, is likely to influence targeted countries to increasingly adopt defensive stances and focus on security operations at home, including tightening immigration controls. Simultaneously, terror attacks, both lone-wolf and organized, are likely to grow in frequency and intensity[12] as counter-terror operations and strategies are implemented and terror organizations are challenged in key regions.

As technological advances continue over the next eight years, unmanned and autonomous, deep learning machines will likely see widespread adoption in both defense and commercial markets. As unmanned technology becomes increasingly salient across societies and militaries, “physical conflict could occur between unmanned systems. The opportunities for bloodless attacks could lower the threshold for conflict”[13]. China’s

technological adoption may rival that of the United States and could very well match the U.S. ability to project power regionally and globally. Russia's military modernization, scheduled to be complete by the mid-2020's[14], includes fleets of modernized fixed-wing aircraft (about 700 aircraft in total), new Borei-class ballistic missile submarines, and improvements in ballistic missile technology; all of which could pose regional and global threats to the United States and its allies.

Geopolitical movements, such as populism and isolationism, are likely to spread due to diverging security priorities, economic disparities and demographic diversity, especially across Western and Eastern Europe, prompting even more draconian immigration regulations and impacting economic and allied relationships. While this trend may slow or reverse within 4-8 years, the effects are likely to last for much longer. International institutions such as NATO and the EU will adapt to the change more slowly and it may take years for a stable rhythm to develop again. Policies emerging from these movements may prove so extreme that domestic movements against isolationism pick up momentum, the backlash against them may be more immediate and the West may see a rapid return to more liberal policies and a re-engagement with globalization, aiding in the share of emerging technologies and security cooperation.

In order to meet the complex and overlapping challenges of this time period, the United States and its partners will likely look to develop forces that can rapidly and adaptively face a broad range of threats, across varying regions and within multiple domains. In the current zeitgeist, the United States may more critically assess the costs and benefits of direct intervention in foreign conflicts, thought it will likely still have to deploy forces to address a major crisis at some point while simultaneously managing

ongoing lower-level conflicts. The ability of the United States to credibly deter and if called upon, decisively defeat enemies and defend interests will very likely be tested over the next eight years.

2025-2033

By 2030, the world could look significantly different than it does today. There are several trends occurring now that will hit their peak in the 2025-2033 timeframe[15], including economic growth in Asia, shift in power among traditional hegemons and changes in the nature of power and governance. While these trends are subject to some wax and wane, it is likely that the main threats facing the United States will emanate from the culmination of these major shifts in the security environment and that some risk factors seen in the previous timeframe will come to fruition in this period.

The projected growth of Asian economies is projected to overtake that of North America and Europe by 2030 in terms of GDP, population size, military spending and technical investment[16]. In doing so, the shift in the balance of power is likely to dramatically shift towards countries like China and India, whose existing relationships with countries such as Brazil, South Africa and Turkey will in turn raise their global presence. While the economies of the United States, Europe and Russia will not collapse in any dramatic fashion, their relative declines will be further exacerbated by strong growth in other regions. Influence, as a result, may wane. As these countries grow in economic strength, so will their ability to pursue technological advancements and 21st century manufacturing.

Climate change consequences are projected to significantly worsen in terms of increased occurrences of extreme weather events, more extreme droughts in dry areas and significant and frequent flooding in wet areas. The Middle East, Northern Africa, Western Central Asia, Southern Europe, Southern Africa and the Southwest United States will be the most impacted by drought while coastal urban cities will face challenges with extreme weather resulting in coastal flooding and threats from storm wave damage. There is a possibility that extreme coastal weather will begin to drive coastal urban cities to expand inland, stressing agricultural areas needed to support urban populations and causing tensions among neighboring nations searching for area to expand. Resource demands will likely become a centerpiece of international tensions, creating opportunity for increased risk of state-to-state conflicts[17].

Technological breakthroughs will become more frequent and significant and public access to disruptive and potentially lethal technologies (precision-strike, cyber, chemical/biological terror, artificial intelligence) will become easier. As processing power and data storage becomes faster, easier and less expensive, governments and societies will be faced with the challenge of preventing the commoditization of classified military technology to non-state actors and individuals. These developments will likely change the face of terrorism, the beginnings of which were seen in the previous era (use of social media for propaganda and recruiting, drone warfare, etc.)[18].

As the international system becomes more fragmented by shifts in power and traditional means of cooperation are challenged, competition and conflict become more likely. It is unlikely, however, that devastating great power conflict (on the level of WWI or WWII) would take place, as the costs would be too high and the technology of the day

would increase the speed, discernment and precision of kinetic and non-kinetic effects necessary for state actors to achieve objectives, thereby reducing the magnitude of conflict as they affect civilian societies. However, the risk of conducting high-level conflicts with significant weaponry may rise. The proliferation of WMD is likely throughout this period and regional instability will only fuel desire for states to produce their own deterrent. As the risk for these types of conflict rises, so too does the risk of nuclear, chemical or biological employment in asymmetric ways.

The role of the United States in this period is an uncertainty. If the U.S. economy remains relatively strong, the U.S. presence on the world stage will not decline significantly, barring any extreme policies that call for U.S. isolationism on a grand scale. U.S. innovation both commercially and militarily will likely continue but will face competition abroad. If the U.S. maintains its allied relationships, security cooperation with the West is likely to continue. The U.S. role in Asia will continue to be challenged and very well may be curtailed by a risen China. U.S. military forces will remain pre-eminent in their training and ability to conduct warfare but will face challenges in terms of threats by proliferating technologies. U.S. force structure will likely need to be as, if not more, flexible as in the previous period and much more technologically capable. Nuclear weapons will likely remain a cornerstone of U.S. security and the improvement of missile defense capabilities is likely, as naval and air capabilities will provide the lion's share of the projection of U.S. power.

2033-2040

The world in this time period is unlikely to be more stable or peaceful and will almost certainly be characterized by instability[19]. The United States will likely remain the pre-eminent military power but will struggle to remain a leader politically and economically. While the continued rise of Asian countries, like China, is not a guarantee, intense competition between major powers, especially over resources, is highly likely. The convergence of globalization, population and emergence of new ideologies and proliferation of WMD is likely to create an environment in which conflict and confrontation, especially at lower levels, is a common occurrence.

Perhaps the biggest threat facing this period is the proliferation of WMD. Not only will proliferation generate instability and shift the global balance of military power, terror groups are more likely to acquire and use nuclear, chemical and biological materials in significant payloads[20]. Increasing cyber capabilities "directed at critical infrastructures, including space assets"[21], complicate this threat picture. As these technologies and materials spread, the United States and partner nations will have a harder time developing successful deterrence policies and strategies. Terror groups are unlikely to hesitate to use devastating WMD capabilities if acquired. As states and non-state actors continue to clash in this period, it is highly likely that those conflicts will exhibit combined capabilities, including WMD, conventional, irregular and high-end asymmetric capabilities.

The United States will face extended years of instability in an environment in which the traditional balance of power is almost guaranteed to shift dramatically. As such, the United States must be able to respond with both agility and flexibility while maintaining strong commitments to U.S. interests, allies and friends. The United States

must also be prepared to protect and defend innovation in both the military and commercial realms in an attempt to remain the pre-eminent military power. U.S. force structure will likely look drastically different by 2040 than it does today. Naval capabilities, unmanned and autonomous technologies, superior air dominance, superior cyber and space capabilities will own the military battlespace.

State-sponsored terrorism is likely to continue or even rise as regional conflicts become more concentrated and frequent. In this event, the likelihood of a non-state actor or terrorist organization acquiring WMD, as well as the expertise and technological knowledge to employ it, may rise dramatically. While the employment of nuclear weapons on a large scale remains unlikely, the employment of one or two in isolated fashion is well within the realm of possibility. Analysts believe that conflicts in this era are likely to include multiple forms of warfare with an increased risk of nuclear employment[22]. The risk for nuclear employment to create EMP effects is higher in this era as "countries with nuclear weapons could be tempted to explode a nuclear device to wipe out their opponent's ability to maintain connectivity…In this instance, nuclear first use would not be used to harm humans as much as to deny opponents use of electronic systems. Space, ocean and near coastal bottlenecks could be areas of nuclear use with little human collateral damage"[23].

The United States will be forced to confront an emerging threat environment "characterized by a wide-spectrum of actors that include near-peers, established nuclear powers, rogue nations, sub-national groups and terrorist organizations that now have access to nuclear weapons and ballistic missiles or may have such access over the next 15

years" and will have the capability to "place the risk of EMP attack and adverse consequences on the U.S. to a level that is not acceptable"[24].

CHAPTER 2: U.S. EXPECTATIONS FOR NUCLEAR DETERRENCE AND EMPLOYMENT WITHIN MODERN WARFARE

The role of nuclear weapons has changed decade to decade and over time their role has been reduced dramatically. From the height of the Cold War, when nuclear weapons represented the bulk of U.S. security, to today where nuclear weapons have a reduced role as a matter of policy. In 2009, at the beginning of the Obama administration, the President gave a speech in Prague outlining his administration's views of nuclear weapons policy and efforts to begin to bring about a world without nuclear weapons. This was the beginning of what many saw as a utopian approach to nuclear weapons, in spite of the challenge of proliferation and modernizing nuclear weapons doctrines.

In the Prague speech, the President vowed to press the Senate to ratify the Comprehensive Test Ban Treaty, reduce the role of nuclear weapons in U.S. security policy and strengthen nonproliferation regimes designed to curb the spread of nuclear weapons technology and information, the most important of which being the Nonproliferation Treaty (NPT)[25]. While nuclear weapons would remain the cornerstone of U.S. security and power projection, their prominence would dwindle.

It was in the same speech that President Obama identified nuclear terrorism as a real threat, stating "terrorists are determined to buy, build or steal one…We must ensure that terrorists never acquire a nuclear weapon. This is the most immediate and extreme threat to global security. One terrorist with a nuclear weapon could unleash massive destruction"[26]. It is not clear if the threat of nuclear EMP was a consideration of the Obama administration in classifying the threat of terrorist employment of a nuclear weapon the most immediate and extreme threat to security. Nonetheless, terrorist

employment of a nuclear weapon was at the forefront of both the administration and security experts' minds. However, nuclear weapons have not traditionally been used as a deterrent for terrorist attacks in the past, mainly due to the high number of civilian casualties that would ultimately result from the employment of a nuclear weapon against the territory inhabited by a terrorist organization. As such, the decision to broadly reduce the role of nuclear weapons in U.S. security policy is not entirely surprising.

For the remaining seven years of the Obama administration, the policy of a reduced role for nuclear weapons continued. The President successfully negotiated the New START treaty in 2010, enforcing new limits on nuclear warheads and missiles, launchers and bombers. While there is nuance in those limits, the reductions were significant and reflected an enduring desire to continue the traditions of arms control following the end of the Cold War. The key provision in New START centered on the freedom of both Russia and the United States to organize their nuclear force structures however they wished, as long as they adhered to the limits imposed by the treaty. In doing so, each state was free to create a force structure that best represented their strategic goals. Today, the United States maintains a triad, emphasizing a capability to support forward presence in allied nations and in maritime environments but has struggled in recent years to provide sufficient funding for much-need modernization on aspects of each leg of the triad. As budget pressures continue, the Trump Administration will face challenges to funding expensive, existing programs like the *Ohio*-class replacement submarines (recently named the *Columbia*-class) and the B-21 Long-Range Strategic Bomber, while simultaneously awarding funding for new programs like the Ground-Based Strategic Deterrent program (the Minuteman replacement) and the Long-

Range Standoff Missile (LRSO). Key leaders in the Pentagon[27] and Congress[28] have expressed commitment to funding these programs, as they are crucial to the credibility of the U.S. nuclear deterrent, however with constrained defense budgets the fight over funding and affordability will be fierce and is, as of yet, unsettled.

While the United States struggles to allocate the necessary funds for its nuclear modernization, Russia's significant and expensive nuclear modernization program, expected to last through at least 2024, is well underway. The Russian Federation has focused on phasing out Soviet-era systems and replacing them with more modern, effective capabilities. The ICBM force structure will be completely modernized with maximized warhead loads by 2021, the old Delta-class SSBNs will be replaced with eight planned Borei-class SSBNs, and the nuclear-capable bomber fleet will feature a new sub-sonic, low-observable long-range bomber by the mid-2020's[29]. The modernization of the Russian nuclear arsenal points to the commitment they have in maintaining a nuclear deterrent far into the future.

The Russians are fairly forthcoming about nuclear weapons strategy in their military doctrine. While the United States generally separates nuclear policy from broader military strategies in official documents, the Russians include their nuclear doctrine as a vital component of the larger military strategy. In 2014, the Russian policy regarding nuclear weapons read as follows:

> "The Russian Federation shall reserve the right to use nuclear weapons in response to the use of nuclear and other types of weapons of mass destruction against it and/or its allies, as well as in the event of aggression against the Russian Federation with the use of conventional weapons when the very existence of the state is in jeopardy"[30].

This policy does not rule out first-use[31] of nuclear weapons but frames the policy within fairly tight parameters. Though the Obama administration explored transitioning to a no-first-use policy in the last year of the administration, they ultimately decided against doing so. Many experts in the field argued against it, citing concerns over possibly undermining the deterrence strategy. Russian nuclear doctrine is much more belligerent and prominent within the broader military strategy than that of the United States.

The Russian Federation has demonstrated a willingness to engage in asymmetric warfare and is believed to include nuclear weapons within their asymmetric warfare strategies. Even as the Russians scaled down their nuclear arsenal following the end of the Cold War, they deliberately maintained the ability to employ nuclear EMP. Dr. Lowell Wood, in his testimony before Congress on Russian nuclear strategy and EMP stated, "EMP strike component exists today in the Russian strategic order-of-battle, moreover likely at its maximum Cold War strength. I very confidently predict that it will be one of the last features of Soviet strategic nuclear weaponry to be retired from the Russian strategic force structure"[32]. It is highly unlikely that any Russian employment of nuclear EMP would happen independent from other asymmetric warfare tactics such as "cyber-attacks, sabotage, and kinetic attacks against the national electric grid and other critical infrastructures – a decisive new way of warfare described by Russian experts as a 'Revolution in Military Affairs'"[33]. Further analysis of the history of Russian EMP and its potential asymmetric employment is explored further in following chapters.

While the United States has dealt with a nuclear Russia for decades, it must also take into account younger nuclear powers (China, Iran, and North Korea) that pose deterrence challenges to the United States and its allies. China's nuclear program has

been active since its first test in October 1964 and has consistently operated under a no-first-use policy, asserting that the Chinese nuclear arsenal is a minimum deterrent against nuclear attacks[34]. The U.S. State Department believes that China's missile arsenal includes short-range ballistic missiles, ICBMs, SLBMs and possibly cruise missiles, all capable of carrying tactical nuclear warheads – and all capable of delivering nuclear weapons to high-altitude to produce EMP effects.

Information about China's nuclear arsenal is limited but its policies on no-first-use and nuclear restraint are well documented. Chinese defense white papers consistently reiterate China's "unequivocal commitment that under no circumstances will it use or threaten to use nuclear weapons against non-nuclear-weapon states or nuclear-weapon-free zones" and there is "no sign that China is going to change a policy it has wisely adopted and persistently upheld for half a century"[35]. However, some experts believe that China views the employment of nuclear weapons to produce EMP effects an unconventional attack, rather than a strategic one, and therefore believes the United States may not view such employment as crossing the nuclear threshold[36]. Like Russia, China has also invested in asymmetric capabilities, such as cyber, and may view nuclear EMP as a broader asymmetric warfare tool. Considering the regional tensions between China and the United States, especially regarding Taiwan and the South China Sea, it is far more likely that China would choose to employ nuclear EMP regionally in an attempt to halt U.S. intervention, rather than over the U.S. homeland.

As rogue states, North Korea and Iran pose special challenges to the United States in the modern warfare environment. Both have active nuclear weapons programs and advancing missile capabilities that are more than capable of producing EMP effects

regionally and may be capable of reaching the skies above the United States to produce intended EMP effects. Both are also conventionally inferior to the United States and gain little by engaging in a conventional conflict in which they are sure to be decisively defeated. Asymmetric use of a nuclear weapon may not only provide states like Iran and North Korea the upper hand, it may postpone or prevent a devastating U.S defeat altogether.

North Korea has often stated its adversarial position towards the U.S. and though Iran has cooperated with the United States on some nuclear weapons issues, the relationship between the two remains tense and unstable. The nuclear agreement between the United States and Iran, the Joint Comprehensive Plan of Action (JCPOA), went into effect in January 2016, lifting nuclear-related sanctions on Iran. It requires that Iran comply with all United Nations security resolutions regarding the Iranian missile program. UN security resolution 2231 endorsed the JCPOA and "called upon" Iran to not undertake any further action on the missile program (ballistic or cruise), including launches, as well as endorsed previous security resolutions aimed at curbing Iranian testing of missile technology[37]. However, Iran has tested missile technology as recently as January 29, 2017, demonstrating an enduring desire to possess sophisticated missile capabilities, the vast majority of which would be capable of delivering a nuclear payload at high-altitude to produce EMP effects.

North Korea poses a slightly different challenge. It is extremely difficult to ascertain exact numbers or facts about the status of North Korea's nuclear program. However, it is believed to be somewhat sophisticated, possibly including at least one thermonuclear device. North Korea has conducted five tests of nuclear weapons in total

and a far larger number of missile tests, though they have enjoyed mixed success. Regardless, North Korea's nuclear ambitions are only growing and they have been clear about their intentions to target South Korea and the West Coast of the United States. Even if targeting of the West Coast is not yet technically feasible, employment of a nuclear weapon in theater would be devastating to U.S. forces and allies in the region and would likely alter the regional balance of security permanently. To date, the United States and South Korea have maintained deterrence in the region through security demonstrations and exercises, however a nuclear EMP attack in theater may render these types of operations incredibly difficult, if not impossible.

The nuclear security environment of today, from a U.S. perspective, largely focuses on the threat from employment of nuclear weapons against the U.S. homeland, U.S. forces in theater and U.S. allies and friends. However, it makes little-to-no mention of asymmetric uses of nuclear weapons like that of nuclear EMP. Perhaps, this is due to the fact that nuclear EMP fell out of public consciousness following the end of the Cold War, or that more prescient threats became more urgent within the current security environment, or perhaps that with an increasingly sophisticated technological environment, the U.S. believes that an actor would not need to resort to the employment of a nuclear weapon to produce effects similar to EMP. Whatever the answer, it is clear that U.S. deterrence strategy is not focused on the threat of nuclear EMP by state adversaries, rogue states or terrorist organizations but on more traditional nuclear deterrence challenges.

CHAPTER 3: NUCLEAR EMP – A HISTORICAL OVERVIEW

Nuclear electromagnetic pulse was, in many ways, an unexpected discovery. In the early years of the Cold War, the United States and the Soviet Union were racing to produce large arsenals of nuclear weapons and testing of those weapons was happening frequently. In 1961 and 1962, both countries began to test nuclear weapons at high-altitude, during which they observed the first effects from the electromagnetic pulse produced by the detonation of the weapon. Only a total of 20 high-altitude nuclear weapons tests were conducted between the Soviet Union and the United States, during which EMP effects were observed but not deliberately sought out[38]. The Soviet Union conducted seven such nuclear weapons tests above their own territory of Kazakhstan between 1961 and 1962, all of which demonstrated EMP effects such as observable damage to transformers and collapsed critical electric infrastructure. The weapons tested were mainly "low-yield warheads, at least one probably an Enhanced Radiation Warhead that emitted large quantities of gamma rays that generate the E1 EMP electromagnetic shockwave"[39].

The most prominent of the U.S. high-altitude tests was in July 1962, named "Starfish Prime". The nuclear weapon was 1.45 megatons[40] and was detonated at a height of 400 kilometers above Johnston Atoll in the Northern Pacific Ocean. In Hawaii, almost 1,400 kilometers away, the "effects were bizarre and almost entirely unanticipated. One effect was an electromagnetic pulse, but nobody knew it was going to be anywhere nearly as large it proved to be. They had all this data and they didn't understand very much of it, including the EMPs that had been observed and the effects produced…all kinds of electrical disturbances were seen over 1000 kilometers away in Oahu"[41]. The EMP

produced by the detonation “interrupted radio broadcasts, caused streetlights to malfunction and burglar alarms to sound and resulted in electronic failures across the islands”[42]. The night sky above Hawaii lit up with thermonuclear glow and about one third of the satellites in low-earth orbit were damaged or destroyed[43]. Figure 1 demonstrates the path of the EMP the further it travels from the site of detonation and shows how altitude has a direct correlation with effect. Had Starfish Prime been detonated at a lower altitude, the EMP effects would have covered a much smaller area and likely would not have affected electrical systems in Hawaii at all.

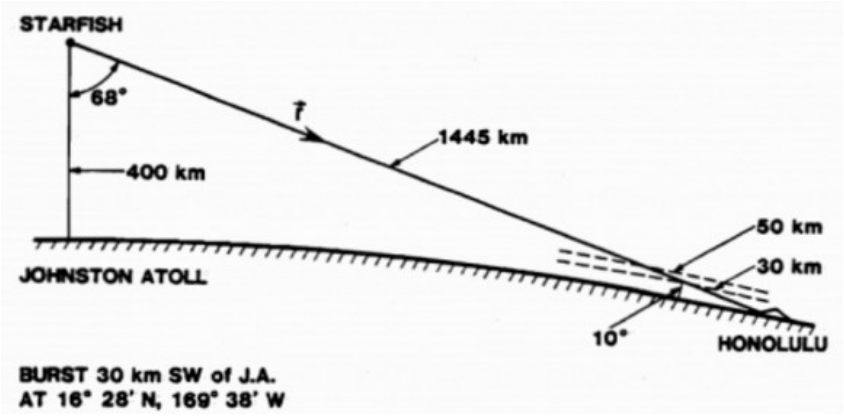

Figure 1. EMP Range of the Starfish Prime Nuclear Test[44]

As these effects were observed in subsequent tests by both the United States and the Soviet Union, the scientific nuances of producing the desired effects became clearer. A high-yield nuclear weapon detonated between 40 and 500 kilometers above the earth’s surface (exo-atmospheric) is by far the most effective. Ground-burst nuclear weapons produce EMP at thousands of volts per meter but only over short distances. The other effects of ground-burst nuclear detonations typically outweigh any EMP effects. High-altitude nuclear detonations, however, produce extremely strong EMP over very wide distances with no physical threat to humans from the fireball, fallout or blast effect. The radiation produced from the burst will not interact with other atoms until they reach the

top level of the atmosphere, causing them to excite and travel along the earth's magnetic field at an extremely accelerated rate over a vast area. Electromagnetic waves create extremely high electric field strengths, producing thousands of volts in a split second pulse, overwhelming electrical systems, especially unprotected equipment. The greater the altitude, the more widespread the area effected and the greater the likelihood that low-earth orbit satellites experience interference or are damaged[45].

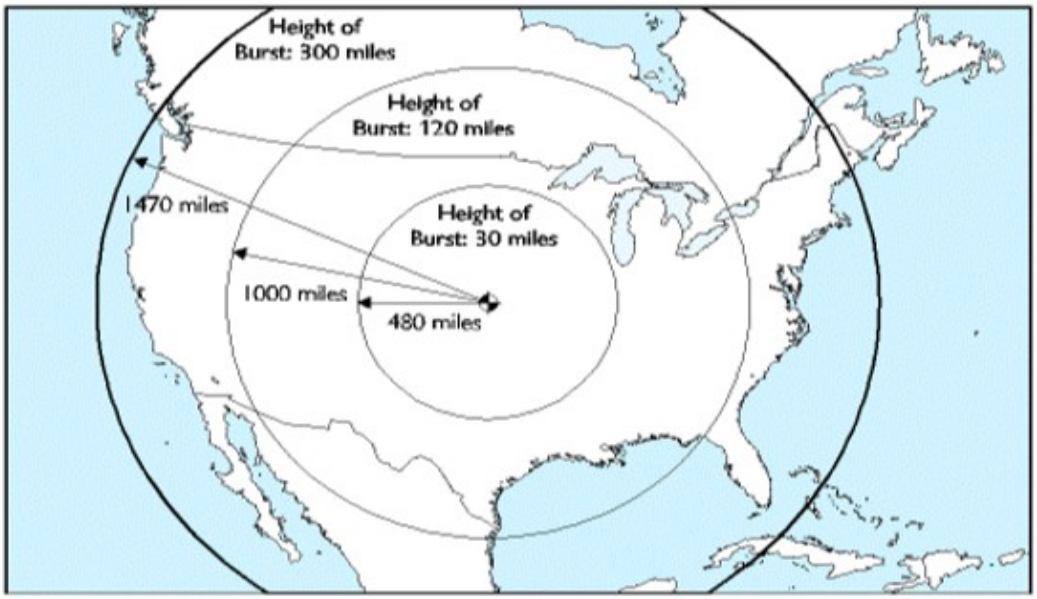

Figure 2. Area Effected by EMP Determined by Height of Burst[46]

Two types of basic damage occur in electrical systems due to electromagnetic pulse: physical damage, such as short-out and burning, requiring replacement or repair and operational upset requiring reboot or full reset of the system[47]. This type of damage was observed in civilian infrastructure, such as traffic lights and electricity to homes, and communications infrastructure, such as radio broadcasts and telephone lines during both the Johnston Atoll tests and the Soviet tests above Kazakhstan. Once affected, electrical systems could take days to repair or months to replace. The Soviet Union, after witnessing these types of effects in Kazakhstan, began to develop strategies that included

the employment of nuclear EMP against the U.S. homeland, with the goal of "paralyz[ing] our military systems, as well as civilian critical infrastructure. The Russians were also hoping it would interfere with emergency action messages to all forces, including ballistic nuke submarines"[48].

The United States developed Cold War national capabilities, such as the Ground-Wave Emergency Network (GWEN)[49], to protect communication networks from EMP effects and worked to harden the nuclear weapons infrastructure in the event that the Soviet Union would attempt to damage or destroy the United States' ability to communicate or respond to Soviet aggression. During the Cold War, it was assumed that if nuclear EMP were to be employed, it would be done in an effort to cripple the ability of the other to respond before a devastating second strike. However, because there were so few high-altitude nuclear weapons tests and the numbers of nuclear weapons on each side so high, there was no guarantee that an EMP attack could cripple the whole of one side's nuclear arsenal, and therefore not guarantee the prevention of a retaliatory strike. It was also clear that *any* employment of a nuclear weapon would result in nuclear retaliation, not just a ground- or air-burst. The deterrence that governed the battlespace of the Cold War was fairly straight forward and understood by both sides. The guarantee of mutual destruction combined with even a small doubt in the capability was strong enough to prevent an EMP attack by either side.

However, even in the Post-Cold War environment, concerns over EMP remained fresh in the minds of Russian strategic leadership. The Norwegian rocket launch incident in 1995 was interpreted by the Russians as a U.S. SLBM launch designed to "take out the general staff and paralyze the forces to enable a surprise attack. They would expect a

single missile from a close location. This was a week after they lost the battle of Grozny. They thought, if the roles were reversed and the U.S. military had suffered a defeat in the Cold War, [the Russians] would complete the process and at some point deliver a coup de grace against the United States…they were waiting to see if the U.S. would launch a surprise nuclear attack to finish off Russia and finalize its Cold War victory"[50]. While the United States largely moved on from the Cold War and has, by all measures, thought of nuclear EMP as a threat of that era ever since, the Russians have not. Scientists of the Russian Federation have identified nuclear weapons as unique in their ability to create widespread EMP. Efforts to create conventional weapons that have the same effects have been challenging: "It is practically impossible for non-nuclear means to concentrate energy that is in any way comparable with that of a nuclear burst"[51]. As Russian asymmetric strategies of war developed and modernized to include cyber-attacks, information campaigns and sabotage campaigns (small arms, bombs), the strategy for employment of nuclear EMP evolved simultaneously. In 2004, Russian Major General Vladimir Belous wrote the following in a public article:

> "Space-based and ground facilities of the information-reconnaissance system, without which the missile defense system will prove to be 'blind, are especially vulnerable in this sense [EMP]… 'blinding' of enemy territory by disabling his electronic and power network is also possible. American specialists determined that in case a large nuclear charger were detonated at an altitude of hundreds of kilometers above the geographic center of the United States, the State of Nebraska, a powerful electromagnetic pulse will disable electronic and power systems on the territory of the entire country for a certain time"[52].

The same year, Russian Captain, First Rank, H. Rezyapov wrote an article entitled "Asymmetric Threats to the National Security of the United States" in which he postulated, "Such a blast would simultaneously take out of action almost all of the

satellites orbiting above the United States… and affect up to 90 percent of the territory of the United States by the action of its EMP"[53]. Russia has not ceased to incorporate nuclear EMP into its strategy and finds great value in the capability outside of the Cold War era.

The Post-Cold War world not only saw disparities in the way Russia and the United States viewed nuclear weapons and their employment, it experienced significant growth in the number of states which possess nuclear weapons. U.S. allies like the U.K. and France, China, Pakistan, India, Iran and North Korea all became states capable of devastating destruction through the use of nuclear weapons, and each state's strategy for those weapons differs depending on the security situation in which they operate. For the purposes of this analysis, China, Iran and North Korea are the focus, though any of the remaining states could employ nuclear weapons for EMP effect and greatly influence their own strategic situations.

The U.S. Department of Defense reports that China has included nuclear EMP as part of its larger asymmetric strategy since 1999, though has spent more time pursuing conventional directed energy and electronic warfare weapons as well as exploring space and counter-space capabilities, which it views as inevitable factors of future asymmetric warfare[54]. Technical papers on EMP appear regularly in Chinese technical journals, such as one published in a Chinese military digest in 2002, which stated "EMP warheads will make it much easier to cross the nuclear threshold"[55]. The Taiwanese government, as a possible target of nuclear EMP, has been writing about Chinese EMP capabilities since at least 1992. One such report in October 2003, reported that "China is engaged in quantitative production and deployment of EMP micro nuclear warheads"[56]. According

to a Wall Street Journal article in the same year, "China recently published an article on EMP in a Chinese-language technical journal. To make sure the U.S. got the message, the article appeared in English'"[57]. Though China retains its commitment to a no-first-use policy, it is clear that as the Chinese thinking on nuclear weapons employment has shifted over time, especially in terms of the employment of a nuclear weapon for EMP effects. In the eyes of Chinese defense strategists, nuclear EMP "will make it much easier to cross the nuclear threshold"[58].

Though Iran has not directly stated an intention to acquire EMP capabilities, it is widely believed to be actively pursuing the capabilities needed as part of its nuclear and missile programs. The JCPOA succeeded in slowing the Iranian nuclear program, delaying it about a decade. However, the agreement has done little to slow the progress of Iran's missile program. Some experts believe that "the military utility of Iran's ballistic missiles is limited because of their poor accuracy"[59] however, the capabilities required to successfully employ nuclear EMP do not require accuracy, "it just has to go up. It's well within the capability of even an earlier Scud missile, of which thousands have been produced – it just has to have nuclear weapon on top"[60]. This does not require re-entry capabilities or sophisticated targeting systems. Iran's missile testing so far has demonstrated their ability to launch "their versions of Scuds off of the Caspian Sea - not from land, but from the sea - and launched them over land. And we've also seen them launch missiles that have gone up and apparently exploded near their highest altitude – when you put those two ideas together – that is an EMP attack"[61]. As a rogue state, Iran is notoriously vague and secretive about its capabilities and intentions. It is difficult to determine whether nuclear EMP is truly within the offensive strategies of Iran however,

if desired, it would not be a technical stretch to accomplish. Finally, Iran's history of state-sponsored terrorism is especially troubling in terms of nuclear EMP and will be explored and analyzed in further chapters in the context of the modern threat to the United States.

North Korea, as previously analyzed, has tested nuclear weapons for over a decade and is well aware of the ability to produce EMP effects, especially against U.S. and allied forces in theater. South Korea has long been concerned about the threat of nuclear EMP from North Korea and has published many articles in academic and security journals concerning the threat to low-earth-orbit satellites above the region as well as the risk of ensuing panic among U.S. forces in the region[62] if or when damage is done to forward-deployed U.S. capabilities. Though there is little data, much like Iran, to concretely determine that nuclear EMP is among the capabilities North Korea is attempting to acquire, recent rocket and missile tests into the Sea of Japan[63] show that North Korea may indeed be capable of inflicting nuclear harm or nuclear EMP in theater on U.S. military assets in Japan or South Korea.

Nuclear weapons have changed little since the Cold War but the nature and strategy of their employment, especially in terms of nuclear EMP has evolved. While asymmetric warfare is not a new concept, the frequency with which it is undertaken and the use of the capabilities it involves are purely modern. For many of the states discussed, the employment of nuclear EMP is not thought of or strategized as a singular event, but as part of a larger whole. To best understand why this is so and why states and non-state actors may find nuclear EMP appealing, one must first understand the effects nuclear

EMP would have on the United States, its infrastructure, military capabilities and citizens.

Modern Day EMP Vulnerabilities

Older technology, such as the previously mentioned vacuum tubes of the 1960's, is "one million times less vulnerable"[64] than today's technology and effects were still observed more than 1,400 kilometers away from the Starfish Prime detonation. To best understand the utility of nuclear EMP, one must first understand the vulnerabilities inherent in today's electronically-dependent world. The United States has long been known as an innovative nation, one which has experienced leaps and bounds of technological advancement. Today, the United States is more technologically advanced than ever before and electronics, telecommunication systems and electrical systems form the cornerstones of a thriving U.S. society (transportation, banking, water and agricultural production and dissemination, communications, etc). However, these critical infrastructures within the United States are very poorly protected, not just from events like nuclear EMP but also from natural disasters or terrorist attacks. These vulnerabilities are well-known among adversaries and both invite and reward attacks like cyber, sabotage and nuclear EMP; an adversarial "cheap shot", if you will.

In 2001, the Commission to Assess the Electromagnetic Pulse Threat was established to study the vulnerabilities of critical U.S. infrastructure systems to nuclear EMP attack. The commission evaluated all aspects of U.S. infrastructure as they are dependent upon one another to function in a meaningful way. What the commission found was that this dependency created significant challenges for recovery after a nuclear EMP attack. In 2008, the Commission again assessed the critical infrastructure of the

United States and found it to be extremely vulnerable to the effects of nuclear EMP, in such a way that any devastating attack is considered an existential threat to the United States. Below are the elements of U.S. critical infrastructure and how each may be affected by nuclear EMP.

Electrical Power

The U.S. electric grid is composed of networks of local electricity supplies, with large-capacity electric transmission hubs few and far between. In such a setup, even small upsets in the system can cause functional collapses and large disturbances like "EMP-level effects could degrade or collapse 70 percent of the country's electrical service in one instant"[65]. The system is designed to withstand disturbances like lightning strikes, but in limited areas, not overwhelming, instantaneous high-voltage pulses across vast swaths of the country, which is why the infrastructure relies on a strategy of "islanding".

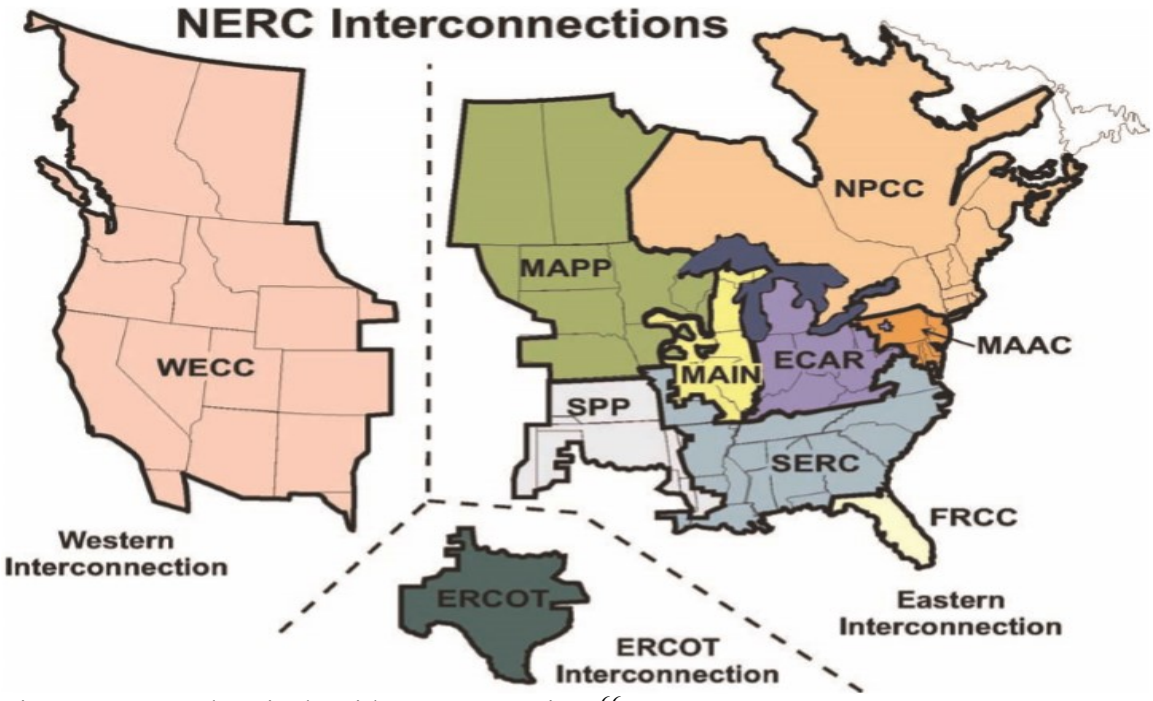

Figure 3. U.S. Electrical Grid Interconnections[66]

When a portion of the system is damaged or interrupted, the other islands continue to operate based on geographic locations of the larger transmission hubs. However, in the event of an EMP attack, numerous (if not all) islands would be degraded or destroyed simultaneously. Though peripheral islands, if functioning, are capable of restarting those in the immediate vicinity, the process would require restarts in rounds from the outside of the damaged area, in. This process would take weeks, if not months, during which the affected population would remain without power. The Commission report argued that with the current setup, the only effective way to restart the system would be through "black start generation"[67]: the process of using hydroelectric, geothermal and independent diesel generators to restart the grid. These energy producers are not as common in the U.S. system and the process would still take significant time. Another complicating element is the overarching need for restart processes to take place. The ability to repair and restart electrical power systems requires communication systems, operational finance systems and transportation systems which need reliable, continuous fuel supply. Fuel supply, communications, transportation and finance infrastructures will all be affected in the event of a strong EMP attack. Restoring those systems is not only essential to the ability to restore power but essential to the quick recovery of civilian order.

Electricity is produced and distributed in various ways in the United States, some more resilient to nuclear EMP than others. Coal-fired generation plants are generally the most durable and normally have on-site fuel storage, so in the event of an emergency, they can produce energy, if only for a short amount of time. Natural gas-fired turbines are more modern and therefore more vulnerable. Nuclear plants, which represent 20% of the

country's electrical generation, have their own safe shut down systems that go into effect in the event of system upsets – their ability to shut down safely is key during EMP but they will be unavailable as generation sources for months following an EMP attack[68]. Hydroelectric power is durable against EMP and produces significant generation but does so unevenly in terms of its geographic availability. Hydroelectric power would be key in recovering service for areas along the coast or dams of large rivers. Hydroelectric power is likely the most helpful in a black start generation process because their geographic locations allow restart to happen from the periphery of the grid.

Electrical power is the number one concern for loss during an EMP attack, as numerous critical aspects of civilian life and the functioning of government at all levels depend upon an operational power grid. A single EMP attack "may be strong enough to seriously degrade or shut down a large part of the electric power grid in the geographic area of EMP exposure effective instantaneously…Should significant parts of the electric power infrastructure be lost for any substantial period of time, the Commission believes that the consequences are likely to be catastrophic, and many people may ultimately die for lack of the basic elements necessary to sustain life in dense urban and suburban communities. In fact, the Commission is deeply concerned that such impacts are likely in the event of an EMP attack unless practical steps are taken to provide protection for critical elements of the electric system and for rapid restoration of electric power, particularly to essential services"[69]. The good news is that protecting, or hardening, key generation capabilities in strategic geographic locations within the system would be enough to create a network capable of quick restart in the event of a devastating attack. Hardening and protection of key capabilities also contributes to deterrence of an attack in

the first place. If it becomes clear that the United States has taken significant steps to protect critical infrastructure from damage or disruption, the risk v. reward calculus shifts and an actor may not believe that an EMP attack would have the desired effects but still prompt a U.S. response.

Telecommunications

The immediate aftermath of the attacks on September 11, 2001 best illustrate, on a smaller scale, what may happen in the aftermath of an EMP attack in terms of the disruption or loss of telecommunications networks. Personal telecommunications, the vast majority over cell phone networks, were disrupted up and down the east coast simply due to call volume which overwhelmed the system and caused cascading failures. Radio communications between first responders were patchy and communication at ground zero was confusing and incomplete. Perhaps the most alarming failure in communications networks was at the federal level. According to the staff report of the September 11th Commission, the Defense Department's National Military Command Center initiated a conference call about the ongoing situation but had trouble including the FAA, who had information about the hijackings: "Operators worked feverishly to include the FAA in this teleconference, but they had equipment problems and difficulty finding secure phone numbers. NORAD asked three times before 10:03 to confirm the presence of FAA on the conference, to provide an update on the hijackings. The FAA did not join the call until 10:17"[70]. By the time a complete picture of the hijackings was garnered through information sharing of the FAA and DoD, the Pentagon had been attacked as well. Though communications infrastructure was not directly targeted on September 11th, the event highlighted difficulties and vulnerabilities within the telecommunications system as

well as its connection to other aspects of the national security architecture. The interruption in communications affected key financial markets and posed liquidity risks for U.S. finances. Business continuity and financial stability are essential in the recovery effort and are closely tied to U.S. national security. In the event of an EMP attack targeted to destroy these systems, the results could be much more devastating and long-lasting. Unprotected communication within the affected area would be impossible and operational areas would be severely degraded due to overwhelming call volume. Concerning federal communications, the Commission reports of 2004 and 2008 recommended that the federal government ensure the Government Emergency Telecommunications System is operational and protected, as the four types of communications within it are unique in their ability to withstanding EMP[71]. Wireline communications are durable but may be degraded within the affected area; wireless communications are likely to be destroyed and inoperable (unless they are powered down at the time of attack); the radio communication sub-system is not widespread but where it is connected to antennas, power lines and telephone lines it is highly vulnerable. Radio communications not connected to those assets at the time of attack will likely be operational; and low-earth orbit communications satellites may be degraded or inoperable from radiation damage depending on the altitude and magnitude of the detonation[72].

In April 2015, as part of the government's effort to "safeguard the command's sensitive sensors and servers from a potential EMP attack"[73], NORAD decided to move critical assets, like servers, sensors and communications equipment, back into the bunker at Cheyenne Mountain, Colorado, the Cold War cavern built in the 1960's to safeguard sensitive military communications and technology from a Soviet EMP attack. Raytheon

was awarded a $700 million, 10-year contract to provide sustainment and maintenance services to "help the military perform accurate, timely and unambiguous warning and attack assessment of air, missile and space threats"[74]. The facility was closed down about a decade ago after the military deemed the threat low enough to move the operations to Peterson Air Force Base nearby. It is possible that this is a first step in protecting sensitive communications as tensions with the Russians are once again on the rise.

Banking and Finance

The American economy, one of the largest and strongest in the world, depends upon electrical systems to run effectively and globally. The financial services industry is comprised of a network of systems that process instruments of monetary value (deposits, loans, funds transfers, savings, etc.) through banks and depository institutions, including the Federal Reserve, investment companies, and industry utilities such as the NYSE. Without functioning electricity and computer systems, the industry would be crippled. These are the means and resources that provide the U.S. population with the ability to buy food, fuel and essential goods and services. Without it, the chances for chaos to erupt in a short amount of time are very high. Of all the institutions affected by EMP, banking and finance come second only to the electrical grid. There is a direct link between the economic security of the nation and national security. The EMP Commission reports identified the Department of Homeland Security, the Federal Reserve Board and the Department of the Treasury as the agencies responsible for ensuring there are mitigation tactics and recovery strategies in place for events like EMP[75]. Even if recovery takes weeks, this is one sector which must recover fully.

Fuel and Energy Infrastructure

The transport and dissemination of fuel and energy depends upon electronic control systems, real-time data flows, communications and process control systems. Operation of oil refineries and other fuel production technology requires an operational electric system. In the aftermath of an EMP attack, lack of access to fuel further exacerbates the challenge of restarting the electric grid and providing transportation to the civilian population, who may be attempting to leave affected areas. Access to fuel also impacts the ability of the government to respond to crises stemming from EMP attacks, such as food and water shortages and medical emergencies.

Transportation

Transportation in the United States occurs in several forms: rail, road, water and air. A nuclear EMP attack would affect all four of these, but in different ways. Transportation services in the United States are increasingly reliant on information technology and public information networks and disruption even at the local or regional level can have national effects. The significant degradation of the transportation infrastructure is likely in the immediate aftermath of an EMP attack[76]. This would include wide-area gridlock (traffic light malfunctions, temporary or unrecoverable engine shutdown), the cessation of rail transportation (lost communication with rail traffic control), air traffic grounded (lost air traffic control) and port closures (commercial power and cargo hauling capabilities inoperable).

There are mixed reports about the risk to airliners in flight during an EMP attack. While it the effects of EMP on airliners has not been widely tested, it is believed that more modern airline designs, such as the Boeing 777, may experience failure in flight in the aftermath of EMP because of increased reliance on computerized technology in the

newer models[77]. If this were to in fact occur, immediate deaths from EMP would climb dramatically due to the number of airlines in flight over the United States at any given time. In the aftermath of an EMP attack, the U.S. government and the FAA must find a way for planes in flight to land safely, without an operable air traffic control. DHS and the FAA will need to coordinate extended no-fly periods and perform assessments on the air traffic control systems to determine how quickly it can be recovered[78]. While the airline industry is not critical to the survival of the United States, the impact on civilian life and economic health of the nation would be extreme and long-lasting.

Railroad transportation is designed to operate under high stress but they often require ample warning time, in the case of severe weather, for example. There will be little to no warning for an EMP attack, giving railroad operators no time to prepare for delays, prioritize shipments and enhance safety. Long delays and disruption on railroads would likely cause further disruption in the distribution of food, water and fuel during a crucial time when the civilian population will be in need.

Similar to airliners, the effect of EMP on vehicles is debated. Newer model cars with onboard computers are likely to be more affected than older models and cars powered off at the time of the electromagnetic pulse are likely to be completely operable, regardless of the technology inside. However, the impact of EMP on vehicles does not just affect the mobility of civilians, it affects the transportation of vital resources like food, water and emergency personnel. Without viable transportation, the ability of distributors to get food out to grocery stores from regional warehouses would be severely impacted. Grocery stores typically stock enough fresh food for three to five days while warehouses stock about a month's worth[79]. Panicked populations are likely to buy out

grocery stores in the immediate aftermath of an EMP attack, adding to concerns about food distribution and civil order. The Stafford Act[80], an act passed to authorize the President to ensure that emergency mass feeding and distribution is able to occur efficiently, could be amended to provide for plans to protect, ration and deliver food from both government and private sector stockpiles and provide plans for distribution in the event of a national emergency. The Department of Homeland Security would act as the lead agency responsible for coordination and dissemination of food assistance in partnership with the Departments of Agriculture and Defense. Similarly, the distribution of water would be challenging. Though water facilities are designed to be protected from threats by terrorists and natural disasters, EMP is not currently listed as a threat consideration for water treatment or distribution facilities. Lack of access to food and water combined with limited access to transportation could result in civil disorder, such as widespread looting and crime.

Though employment of nuclear EMP does not typically result in immediate civilian casualties, weeks or months without proper access to food, water or electricity could very well result in widespread civilian harm or death. Emergency services would be in high-demand from the beginning of the crisis and throughout the recovery. However, the technology relied upon by emergency personnel, such as mobile radio communications equipment, commercial telephone networks and civil power networks, is likely to be degraded or destroyed by EMP which would severely impact response time, logistics and critical health operations. Increased demand for emergency services will overwhelm any operational systems, introducing further complications.

Government, Military and Space Assets

Maintaining continuity of government in the immediate aftermath of a crisis such as EMP is priority number one. Secure communications between the President and senior officials must remain intact in order to provide stability to the public and command responsive actions if any are to be ordered. National capabilities were designed and fielded during the Cold War but may need to be updated to reflect the complexity and sophistication of today's government and military structure. Current policy requires protection from EMP effects on U.S. strategic forces and command and control[81]. Certifying and maintaining the credibility of U.S. strategic forces is challenging and, as observed by the Commission in 2004, EMP protections on such systems have experienced "relaxed discipline"[82]; the survivability of U.S. nuclear forces in particular may have become an "acceptable risk" post-Cold War[83]. However, for U.S. strategic forces to contribute to deterrence of an EMP attack, the ability of forces to withstand EMP effects and reliably respond or retaliate must be certified regularly and with public acknowledgment.

U.S. general purpose forces are consistently technologically superior to those of the vast majority of the world. Advanced warfighting and joint combat operations depend upon technologically advanced computing, information flow and superior communications, all of which are powered by advanced electronics and space-borne assets. This highly superior technology is extremely vulnerable to the effects of EMP, making them an attractive target for asymmetric deployment of nuclear weapons against U.S. forces and infrastructure terrestrially and in space. Low-earth orbit satellites that enable up- and down-link capabilities, GPS and PNT, remote sensing, weather

forecasting, imaging, and other mission critical capabilities are politically, militarily and economically valuable. They are also among the most vulnerable when it comes to damage and destruction from EMP effects. The Commission to Assess National Security Space Management and Organization cited low-earth orbiting satellites as particularly vulnerable to "severe lifetime degradation or outright failure from collateral radiation effects resulting from EMP attacks on ground targets"[84]. Without operable space assets, the ability of the United States to operate in cross-domain operations, joint operations or communicate in any meaningful way would be degraded to a significant degree, if not made nearly impossible. Essentially, large swaths of the U.S. military would be operating deaf and blind. While it is not practical to fund EMP protections on every military capability, space assets such as satellite navigation systems, satellite and airborne intelligence and targeting systems, and missile defense systems must be protected from every level of EMP effect to ensure the continued operational capability of strategic assets of the U.S. military at home and in theater. To implement EMP protections as acquisition and design requirements for critical military assets, like space capabilities and critical platforms, it will "require the personal involvement and cooperation of the Secretary of Defense, the Chairman of the Joint Chiefs, the Service Chiefs, and the appropriate congressional oversight committees"[85].

In 2008, the EMP Commission released a second study on the critical infrastructures of the United States, in which the Commission expressed serious doubts that the U.S. federal government has "sufficiently robust capabilities for reliably assessing and managing EMP threats. The country is rapidly losing the technical competence needed"[86] within the national labs, industry and government communities.

Inaction may increase the EMP threat to the United States due to widespread and openly available analysis showing that the United States is highly vulnerable to large-scale attacks on electrical critical infrastructure. Without visible, publicly reported investments that show a directed effort to protect infrastructure against EMP-style effects, adversarial actors may be incentivized to take advantage of this critical U.S. vulnerability.

CHAPTER 4: THE 2003 NORTHEAST BLACKOUT – A CASE STUDY

On August 14, 2003, in what utility officials called "a blink-of-the-eye second"[87], eight states in the Northeast and Midwestern United States, as well as Southeastern parts of Canada, experienced electrical blackout after a power line sagging due to heat and increased energy demand brushed against overgrown vegetation. The failure in the line caused others in the same network to fail, which ultimately resulted in a "massive outflow"[88] of power as other lines and ground systems tried to cope with the extra energy. Eventually, the overtaxed systems shut down and cascading failures began to result in massive power failures across the larger grid. The effects of the blackout were widespread and significant; in the course of an afternoon, more than 50 million people were without power. Airports in the region experienced significant delays due to air traffic control disruption, commuters on subway trains at the time of the blackout had to be evacuated as trains were left stranded, and traffic lights remained out or blinking for hours causing widespread gridlock. Telecommunications companies reported disruption in service due to call volume compounded by failures at several cellular transmitters reliant on electricity providers within the affected area. ATM's and bank teller machines were inoperable, leaving citizens without cash on hand unable to purchase flashlights, batteries or other emergency supplies and incidents of looting were reported in downtown New York City. Perhaps the most dangerous effect of the blackout was the loss of air conditioning in the height of summer. Citizens vulnerable to the heat began to overflow emergency rooms which were relying on emergency generators for power. Some reported vehicle-related injuries due to traffic accidents and pedestrians being hit by cars. The ability of emergency personnel to navigate dark and gridlocked streets to reach those in

need was severely hampered. The stock exchange had closed for the day and was not itself disrupted, though the economic impact of the blackout was later calculated to be near $6 billion[89].

Almost ten years later, in 2012, a report published in the journal Epidemiology cited nearly 100 deaths that the blackout directly caused or contributed to. The study found that 12 individuals perished due to accidents (vehicle or otherwise), 38 by cardiovascular conditions (heart attacks, some triggered by panic), three from respiratory problems (exacerbated asthma) and 37 from various other health conditions. The New York City health department blamed six deaths on carbon monoxide poisoning due to the blackout[90]. The study concluded that "power outages can immediately and severely harm human health" [91], whether as a direct impact or a contributing factor.

The cause of the 2003 Northeast blackout, as determined by a comprehensive report by the Department of Energy and the North American Electric Reliability Corporation (NERC), was identified as long-term inadequacies within the system and institutional failures and weaknesses resulting in widespread cascading failure. The report separated the causes into four categories: failure to assess and understand the inadequacies in the system, inadequate situational awareness, failure to keep vegetation growth under control, and failure of organizations to provide real-time diagnostic support.[92] In simple terms, the 2003 blackout was a result of a single failure compounded by human error and widespread system weaknesses.

Prior to the blackout, NERC set standards for the electrical grid system but they were largely "administrative and technical rather than results-oriented" and represented "minimum requirements that may be made more stringent if appropriate by regional or

sub-regional bodies, but the regions have varied in their willingness to implement exacting reliability standards"[93]. Without requirements codified by the Federal Government, the industry created standards and best practices for itself that in many cases were not adequately followed or inadequately communicated to operators responsible for maintaining service, even under abnormal operating conditions. Following the release of the report, Congress passed the Energy Policy Act of 2005, which expanded the role of the Federal Energy Regulatory Commission (FERC), giving the agency authority to approve and enforce energy industry standards and requirements. These standards which were once voluntary, are now mandatory and legally enforceable.

Human error and lack of training also contributed to the blackout. At the station in Ohio where the originating line came in contact with overgrown vegetation, an alarm system designed to alert operators of problems had gone offline more than an hour before the failure and no one in the control room had noticed. The failure of the alarm system prevented operators from re-distributing power to less overloaded transmission lines. Additionally, at the regional power facility in Indiana, a grid-monitoring computer crashed. A technician was able to fix it but left for lunch and forgot to turn the computer back on. Consequently, the regional power station was unable to collect data on issues within the regional grid and their effect on other stations, and as such, could not monitor or take action to prevent the cascading failures[94]. Once cascading failures begin, there is little human intervention can do to stop them. The key in preventing or responding to wide-scale energy failures is maintaining well-trained, prepared staff operators and technicians who have practiced what to do in the event blackout conditions arise. The

report found that “significant additional training is needed to qualify an individual to perform system operation and management functions”[95].

The 2003 blackout lasted for just over two days, though some areas were able to restore power in several hours. The blackout was widespread and disruptive, but not long-lasting and did not severely impact communications capabilities or any capabilities not directly attached to the grid. Independent electronics and vehicles were unharmed. General civility among the population remained intact and widespread panic was avoided. Blackouts like this are a good indicator of how systems typically recover from widespread events and what is needed in terms of technology standards and human intervention and training, but are not always a good measure of the enormity of an attack like nuclear EMP.

First, the recovery period for an EMP crisis would be much longer and more demanding. Unlike blackouts, the infrastructure in an EMP attack would not just be damaged or offline but in some cases destroyed and not just state-by-state or regionally but likely across multiple regions or, if the nuclear weapon is large enough, across the majority of the country. Recovery time from an EMP attack would be exponentially longer and the process more difficult. Replacing the power transmission infrastructure is much more complicated than simply purchasing equipment or capabilities which were destroyed. In many cases, equipment used in this grid is “specially produced and has to be ordered from overseas… and generally takes two years to be manufactured and delivered”[96]. Though transmission units outside of the affected area could begin to restart others as they became repaired, this process would take weeks and gaps would occur where stations were waiting on destroyed units to be replaced. Without protecting this

critical infrastructure from EMP effects, the recovery time will be weeks at a very minimum.

Second, the stability of communities and civilian populations is at far higher risk of collapsing the longer a crisis extends. In longer-lasting recovery periods, communities experience wide-spread looting, opportunism and vigilante civil defense. After disasters, people expect help, and they expect it from federal, state and local governments working in concert. Emotional reactions are compounded by the paralysis of government and emergency services. In the 2003 blackout, civil order remained intact largely because communications infrastructure was unaffected and civilians were largely successful in contacting loved ones and getting information from federal and state officials. In an EMP attack, the ability to do so in a widespread manner is highly unlikely. The first requirement, and most stabilizing influence, in response to a disaster like EMP is the dissemination of information to the public. The second is bringing back the ability of the public to communicate with friends and loved ones they will be concerned about.

Third, and finally, the 2003 blackout affected the ability of state and local emergency services to respond in a limited manner but did not affect the ability of the United States military or government to function. Because the stock market was unaffected, the financial viability of the country remained intact. Government agencies were able to communicate and U.S. national security assets were not degraded or prevented from performing critical missions. All of these critical capabilities are at risk in the event of nuclear EMP. Blackouts rarely test the ability of the Federal Government to protect national security interests and assets, beyond maintaining civil order, however it is in the government's interest to consider the effects of extended blackout in concert

with communication infrastructure loss in national security terms. If the U.S. government and military capabilities are unable to communicate with one another, instability among government will be coupled with instability among the civilian population. Without visible leadership, the credibility of the United States at home and as an international actor will suffer immensely.

The 2003 blackout serves as a useful example of the kinds of effects the United States may experience in the immediate aftermath of an EMP attack. No case study is perfect, as this type of attack has never been perpetrated against a modern civilian population. However, by piecing together examples of widespread outage or damage caused by blackouts, severe weather events and terrorist attacks, important lessons can be learned about what to expect, what may be needed to respond or recover and what can be realistically and economically prevented. This kind of analysis also highlights the vulnerabilities inherent within U.S. systems and policies of response, both of which are well known to U.S. adversaries who wish harm against the United States – whether that occurs in the form of nuclear EMP, cyber-attacks, terrorist attacks or other actions.

Up to this point, this analysis has focused on the effects of nuclear EMP, the capabilities of U.S. adversaries to deliver it and the consequences for the United States should one succeed. The following chapter will take this context and analyze how and why identified adversaries may employ nuclear EMP, how this threat impacts deterrence and what strategies the United States may be able to use to deter the employment of nuclear EMP against the U.S. homeland and U.S. forces abroad.

CHAPTER 5: THE UTILITY OF NUCLEAR EMP

The employment of a nuclear weapon with the intention of creating widespread EMP effects is a viable option of attack for both state and non-state actors. The capability to employ a nuclear weapon in this manner is available to existing nuclear weapon states like Russia and China, rogue states like North Korea and Iran, as well as to terrorist organizations who are able to acquire the capability either through purchase or, less likely, through independent development. The fact remains, however, that employment of a nuclear weapon is a serious action and the effort required to gain the ability to do so is immense. For an actor to expel that amount of effort and to take on extreme political and security risks, the utility of employment must be quite high. This chapter will explore the motivations behind the employment of EMP and why it remains a viable option or goal for adversaries of the United States in the 21st century environment.

Rogue States

The employment of WMD is attractive to rogue states like Iran and North Korea because it provides them an asymmetric response to U.S. technological and conventional superiority and complicates U.S. response options. Rogue states are most likely to employ nuclear EMP as a battlefield component of an "escalate to de-escalate" strategy: employ a nuclear weapon at high-altitude, in theater, to severely hamper the ability of U.S. and allied forces to communicate, maneuver, recover or respond; or employ a nuclear weapon at high-altitude above a U.S. ally or partner, creating a regional crisis and forcing the United States to act or remain out of the conflict; or employ a small nuclear weapon at high-altitude above the United States, demonstrating nuclear weapons

capability, lowering U.S. resolve to respond or intervene in regional conflicts, and impacting the ability of the United States to operate, in a limited manner.

The employment of WMD, or threat of employment, can be useful in influencing the decisions or actions of U.S. allies. It is possible that rogue states would threaten the employment of WMD against U.S. allies, friends or coalition members to frighten them out of cooperation with the United States, either in the form of U.S. basing abroad or political, military and economic support. The strategic goals of rogue states, such as regime survival and regional hegemony, are most threatened by the presence and actions of the United States military in the region.

However, experts today are in disagreement about where North Korea would most likely employ nuclear EMP. While a "Taepo Dong-2 missile launched from North Korea probably could deliver a warhead 300 miles above America, enough to degrade electronic systems throughout the country,"[97] this may guarantee an overwhelming response from the United States that would devastate the North Korean regime. As a strategic option for ending a regional conflict, this action by North Korea is highly unlikely and irrational[98]. There is little utility in perpetrating an attack against the U.S. homeland that would likely result in the end of the North Korean regime, by the hands of the United States or its allies. Far more likely, is the employment of a North Korean nuclear weapon in the atmosphere above the Korean peninsula in an attempt to cripple U.S. and South Korean military capabilities present in theater, possibly as a first step in a larger campaign. North Korean technical capabilities are less likely to be affected by EMP (either through protection or limited sophistication) and would remain operable enough to execute military missions on the peninsula as U.S. and South Korean forces attempted to recover.

However, if the North Korean regime were to perceive that it would not survive a conflict, regardless of U.S. and allied response, it may very well decide to employ nuclear EMP against the U.S. homeland as a final act in an attempt to bring the United States to its knees.

Iran's decision calculus for nuclear EMP is likely very similar. Iran's desire to be the reigning regional power in the Middle East is the driving force behind its missile and nuclear programs. Without either, Iran's ability to project power and influence the regional security environment would be severely limited. Protecting the ability to influence the security dynamics of the region and act as the pivotal regional power is essential to maintaining control and to the survival of the Iranian regime as it currently stands. Employment of nuclear EMP in theater would cripple any regional forces or assets and would enable the regime to act decisively without the threat of intervention, by the U.S. or another regional adversary. Israel has recognized the utility of this strategy and has taken measures to protect its assets and capabilities against nuclear EMP in order to maintain the ability to respond.[99] The United States would be forced to make difficult decisions about potential responses and policy moving forward. Unlike the environment on the Korean peninsula, the United States would be facing a much more complex and volatile security situation with far more chances for miscalculation.

Iran certainly possesses the ability to employ nuclear EMP against the U.S. homeland but, similar to North Korea, has little reason to do so outside of dire circumstances. The risk of an overwhelming response by the United States is much lower if Iran were to employ nuclear EMP in theater. An "escalate to de-escalate" strategy is much more likely to succeed if U.S. civilians and the homeland are unharmed, leaving

the United States' interpretation of proportional response much narrower. However, if Iran were to employ nuclear EMP against the United States homeland, an overwhelming response, nuclear or conventional, is much more likely – even if the deployment of conventional assets is more difficult; the risk-reward calculus is much more skewed. In the case of both Iran and North Korea, the response of the international community to an attack on the U.S. homeland, rather than the employment of nuclear EMP in a crisis or battlefield scenario, would likely be swift and decisive. For two states who value survival above all else, the risk of an attack of such magnitude against the United States at home is far higher than the reward.

Terrorist Organizations

As demonstrated by the attacks of September 11th, "our enemies will seek to attack in ways we are not prepared for, using methodologies that have not previously been tried"[100]. Nuclear EMP represents a unique challenge and opportunity to terrorist organizations. While it is difficult for terrorist organizations to acquire the technology and materials needed to successfully execute a nuclear EMP attack, if executed successfully, the event and its aftermath would be highly visible and widely covered. Terrorist organizations like Al Qaeda and ISIL have publicly announced their desire for WMD capabilities and include "using the technology of directed energy weapons or EMP" as part of their information warfare campaigns[101]. The beauty of EMP for terrorist organizations is its indiscriminate nature: the U.S. military is not the only entity severely affected by EMP; the U.S. public relies on electronic systems that would also be severely impacted, degraded or destroyed. While the non-discriminatory aspect of EMP may deter

a state actor from using it against the U.S. homeland (making it more attractive as a battlefield weapon), a terrorist may very well find great utility in it.

The national security community is divided on how sophisticated the technology required to produce EMP effects must be and, as a result, which actors are capable of employing nuclear EMP. One side believes the technical requirements of a nuclear weapon capable of producing EMP are too sophisticated and as such, are a barrier to terrorist acquisition and use; ultimately, they believe that a crude nuclear weapons package will not produce the desired effects. The weapon must have a trigger mechanism, electronics and complicated physics package as well as be compact enough to fit onto a ballistic missile or other sophisticated missile system[102]. In their view, it is highly unlikely that a terrorist organization could successfully steal these capabilities; yet it is possible they could be purchased. Iran and North Korea are the most likely sellers of ballistic missiles to terrorist organizations, however they are unlikely to do so after spending significant money and time on their own programs while simultaneously incurring political and security risks. The sale of nuclear material and technology is much more difficult and monitored closely by the international community. Programs like Cooperative Threat Reduction, international agencies like the International Atomic Energy Agency and international communities, such as signatories to the Nuclear Nonproliferation Treaty, ensure, to the best of their ability, that nuclear material does not enter the hands of terrorist organizations. However, if a terrorist organization were able to successfully purchase or steal a complete nuclear weapons package, fitting it onto a missile it was not designed for would be equally technically challenging. For an organization to be successful in both areas, it would need significant time, money and

likely capable members or partners. However, cooperation with a terrorist organization, especially for Iran, is not outside the realm of possibility, as it would complicate attribution and pose significant challenges for the United States when determining proportionate response. North Korea is less likely to engage in such activity, as they do not have a long history of state-sponsored terrorism on a large-scale and keep a close hold on their technological achievements. However, the other side of the community argues that the barrier to employment of nuclear EMP is not as high as described here and that EMP effects can be achieved with low-yield nuclear weapons, launched from relatively unsophisticated missiles at close-range. As mentioned previously, all a missile needs to do is go up. If a terrorist organization could, for example, launch a 10kt weapon (the size believed to be in the North Korean nuclear arsenal) with a short-range missile off the coast of the United States from a cargo or transportation ship, it would likely succeed in producing EMP effects up and down the coast of the United States[103].

While the challenges facing a terrorist organization in acquiring nuclear technology and missile capabilities are daunting, they are not impossible to overcome. Once a terrorist organization has acquired the necessary materials and technology, it is unlikely to hold onto it for long. Terrorist use of WMD has long been on the agenda and once acquired, the organization is unlikely to wait to employ it, for fear of losing it to adversaries who locate it and deny their ability to employ it. Depending on the organization, it may be far more useful to employ a crude nuclear device in a more traditional terror attack, such as a truck bomb, than go through the effort to employ a successful EMP attack. How a terrorist organization chooses to employ WMD depends completely on desired effect. If an organization is willing to take a longer view, it may

very well decide upon nuclear EMP due to the existential nature of the threat against the United States.

Russia and China

Unlike rogue states and terrorist organizations, nuclear EMP fits into a larger asymmetric strategy for nuclear weapon states, in this case Russia and China. As has been previously discussed, nuclear EMP does not represent a stand-alone strategy for either of these actors but enables a larger asymmetric strategy to succeed. Nuclear weapons still act as a counter to the conventional superiority of the United States and will continue to do so in relations between Russia and China and the United States. However, the utility of nuclear EMP is in its ambiguity as to whether it is considered employment of a nuclear weapon in the traditional sense and therefore, whether employment of nuclear EMP is considered a crossing of the nuclear threshold. The nuclear EMP policies of Russia and China suggest that these two states believe the risk the United States would view nuclear EMP as a crossing of the nuclear threshold and respond with nuclear weapons is low[104]. The Russian belief in this theory is so strong that they have in the past made threats of nuclear EMP based on it: "In 1999, for example, at a high level meeting in Vienna of a Congressional delegation with senior members of the Russian government, Vladimir Lukin, the chairman of the Duma's Foreign Affairs Committee, angry with American policy in the Balkans, issued the following threat: 'If we really wanted to hurt you with no fear of retaliation, we would launch a Submarine-launched Ballistic Missile (SLBM), [and] we would detonate a nuclear weapon high above your country and shut down your power grid'."[105]

Both Russia and China would benefit from a United States forced to retreat from the global stage as it recovered from a devastatingly successful nuclear EMP attack. Russia would emerge as the militarily superior power and China as the economic super power of the world. Both would enjoy increased influence in their respective regions and face little resistance to their expansionist strategies and territorial claims. Though NATO would likely invoke Article 5 and attempt to respond to Russia, without the capabilities of the United States, the alliance would struggle to match the military might of the Russian Federation. The security environment in Europe would drastically change without the deterrent effect of a NATO backed by U.S. nuclear capabilities. The Baltic States would likely face a rapidly expansionist Russia and events like those witnessed in Crimea, Ukraine in 2013 would be further enabled. China's claims to islands in the South China Sea would largely go unanswered and the security of South Korea, Japan and Taiwan would lessen dramatically. In either case, it is likely that regional conflicts and crises would break out with very limited U.S. aid or none at all. Though cooperation between Russia and China in executing a nuclear EMP attack against the United States is highly unlikely, one would certainly reap benefits from the action of the other. There is a high likelihood that breakdowns in security in both regions would occur, regardless of who perpetrated the attack. Russia and China recognize the opportunity nuclear EMP affords them and has prepared their nuclear weapons and missile systems to be capable of carrying it out. Through viewing nuclear EMP as an asymmetric capability, they increase both the utility of it and the likelihood that it may be employed in today's security environment.

Actor	Threat Level	Target Region	Capability
Russia	Moderate	U.S. Homeland	High-yield NW, Ballistic Missile
China	Moderate	U.S. Homeland/In Theater	High-yield NW, Ballistic Missile
Iran	Low	In Theater	Low-yield NW, Ballistic or Cruise Missile
North Korea	Low	In Theater	Low- or High-yield NW, Ballistic or Cruise Missile
Terrorist Organization	Low	U.S. Homeland	Low-yield NW, Crude Ballistic or Cruise Missile

Table 1. Level of EMP Threat According to Actor

Nuclear EMP presents a unique opportunity to state and non-state actors alike. While the threat of nuclear weapons employment against the U.S. homeland has been reduced since the end of the Cold War, the utility of the employment of nuclear EMP has risen dramatically. U.S. reliance on sophisticated electronics and technologically advanced systems has created a vulnerability that now represents an existential threat to the existence of the United States in its current form. No other threat facing the United States in the 21st century security environment represents greater consequences, regardless of its low likelihood. The following chapter analyzes how the threat of nuclear EMP, as portrayed by the actors discussed here, impacts and challenges traditional strategic deterrence and recommends the best deterrence strategies to reduce the risk of employment or deter attack altogether.

CHAPTER 6: NUCLEAR EMP AND DETERRENCE

Deterrence during the Cold War relied on the mutual understanding that nuclear employment by one side would result in massive retaliation by the other. In the modern warfare environment, massive retaliation has largely fallen by the wayside, replaced by theories such as tailored deterrence, minimum deterrence and escalation control. The act of deterring nuclear weapons employment includes more than the employment of nuclear weapons in return but includes the ability to deny successful employment through capabilities such as missile defense. As the deterrence picture became more complicated, so did the threats. During the Cold War, nuclear EMP was a component of nuclear employment, provoking the same result as detonating a nuclear weapon on enemy territory. There was no daylight between the types of employment one could choose and the response they received. The same is not true for today. Traditional approaches to nuclear deterrence do not fully encompass or address the threat of nuclear electromagnetic pulse. If the United States is to deter or deny the employment of nuclear EMP against its homeland and forces and allies abroad, it must take current deterrence policy and shape it to specifically address this threat, regardless of who poses it.

The 2004 EMP Commission began its analysis with upfront recommendations, one of the first of which was to determine and develop a deterrence strategy designed to counter the threat posed by nuclear EMP[106], which would then be supplemented by improvements in the protections of U.S. critical infrastructure systems and U.S. military assets. As discussed in previous chapters, a tangible step the United States can take in deterring an EMP attack is investing in physical protections of U.S. critical infrastructure, including key transmission lines in the electrical grid, U.S. space assets (military and

commercial), and strategic nuclear forces. As spending on nuclear weapons declined, so did "budgets for programs to harden key satellite, communications and other critical nuclear and non-nuclear supporting equipment and facilities to the effects of nuclear-induced electromagnetic pulse…the failure to spend funds to maintain the hardness against EMP…may be compounded by our increasing reliance on commercial off-the-shelf technology. … If nuclear weapons and supporting systems, such as the systems that warn of a missile attack, do not survive or do not operate as planned, they will not support robust and flexible deterrence"[107]. The United States can also conduct training exercises designed to train civilian and military personnel at all levels of critical infrastructure how to recognize an EMP attack and what to do in the immediate aftermath. Doing so in a deliberate and public manner will not only heighten U.S. consciousness of the threat and prepare both civilian and military agencies for emergencies, but lower the level of high-consequence risk to the United States and make an EMP attack less attractive to adversaries. Reduced consequences have a direct correlation in reducing risk and probability of attack. Additionally if the United States can protect civilian and military assets in a meaningful way, the risk of delayed response due to distraction by the level of devastation at home is far less and would contribute to a credible threat of response. In fact, not investing in such protections, may incentivize an adversary to choose nuclear EMP as a course of action due to their belief that the United States would be blindsided and further incapacitated.

U.S. national security strategies over the years have contributed indirectly to the deterrence of nuclear EMP and the defense of the nation and its allies through taking actions to strengthen alliances to defeat terrorism and strengthen and enforce counter-

proliferation and non-proliferation regimes, both independently and as part of global partnerships[108]. These actions contribute significantly to the deterrence of terrorist acquisition of a nuclear weapon or sophisticated missile technology, but do little to deter the employment of nuclear EMP once already acquired. The same national security strategies have called for increased ballistic missile defense and global precision strike capabilities, both of which increase the ability of the United States to defend against incoming missile threats to the homeland but do little to deter employment of nuclear EMP. Currently, the only missile defense system capable of intercepting and destroying a missile exo-atmospherically is the Terminal High-Altitude Area Defense (THAAD) system. THAAD has only successfully demonstrated the capability to destroy missiles outside the Earth's atmosphere twice[109], one of which was a Medium-range ballistic missile. While this is an achievement in missile defense technology, its contribution to the deterrence of nuclear EMP is less significant. U.S. missile defense systems would need to identify a missile as intended for nuclear EMP and intercept and destroy it prior to its exit from Earth's atmosphere, where it would be designed to detonate for maximum EMP effect. To contribute in a significant way to deterrence or defense against nuclear EMP, THAAD would be required to work far more often and at a much earlier stage than it is currently designed. The capabilities of U.S. missile defenses simply "remain uncertain at best"[110] and do not address the technical challenges of defending against high-altitude nuclear detonations.

Tangible protection measures, specialized training, international efforts to prevent technology and material transfer, and kinetic defenses all contribute to the defense and deterrence of nuclear EMP but do not lower risk to an acceptable level on their own.

These measures must be supplemented by a strong deterrence strategy. Lawrence Freedman, the prolific thinker on deterrence strategy, wrote in 2004 that deterrence "in all cases is about setting boundaries for actions and establishing the risks associated with the crossing of those boundaries…During the Cold War…the study of deterrence became synonymous with the study of the strategic conduct of the Cold War. The confrontation defined the concept rather than the concept the confrontation"[111]. In the case of nuclear EMP, the current view of the United States is much the same; the confrontation defines the concept of deterrence, rather than deterrence of the confrontation defining the landscape in which it exists. To ignore the landscape out of which the threat emanates is to ignore the reasons behind why actors would choose to employ nuclear EMP in the first place. With these reasons understood, the United States must now create a strategy of deterrence that defines the confrontation of nuclear EMP.

For a credible deterrence strategy to be formed around the issue of nuclear EMP, the United States must first be willing to unambiguously designate the employment of a nuclear weapon to achieve EMP effects as a crossing of the nuclear threshold. Doing so upends the strategic calculus of adversaries like Russia, China, Iran and North Korea who believe that the United States may not classify it as such and as a result, may exercise restraint in response[112]. Strategic ambiguity does not serve the United States well when it comes to the threat of nuclear EMP, mainly due to the fact that the very ability of the United States to respond may be hampered by the effects of the attack itself. Strategic nuclear forces will likely survive, and depending on the location of the detonation, regional assets are likely to as well. Though the United States may choose not to respond with a nuclear weapon detonation on the perpetrators territory, it must remain a clear and

viable option. The nature of U.S. employment of a nuclear weapon in response - whether it be a high-altitude detonation over the perpetrators territory, a low-yield, tactical ground burst, or an air-burst targeting military assets – can remain ambiguous, but the United States must be willing to maintain the long-held policy that an action crossing the nuclear threshold will incur a proportionate and necessary response. As Freedman writes, "when using deterrence to defend an interest, it is necessary not only to demonstrate how deterrence will work if challenged but also the nature of the interest to be defended"[113]. Nuclear EMP, as an existential threat, threatens the greatest security interest of the United States: to maintain the security of the homeland, the safety of U.S. citizens and the role of the United States in the world as a leading democratic power.

Establishing a declaratory policy that outlines the employment of nuclear EMP as a violation of the nuclear threshold allows the United States to then tailor the strategy to address the two aspects of the threat: deter employment of EMP in theater and deter employment of EMP against the U.S. homeland. Unlike the strategic nuclear deterrence strategies used today to deter nuclear employment in more traditional ways, deterrence strategies for EMP need not be tailored by actor but by employment scenario. The results for the actor who chooses to employ nuclear EMP should be largely the same, regardless of who the actor may be. For North Korea and Iran, those results likely mean the end of their regime – which speaks to their greatest strategic interest. For states like Russia and China, those results mean devastating response on their homeland with the risk of triggering a large-scale conflict that is outside of their interests and does not achieve the strategic goal they hoped to through employment of nuclear EMP. Terrorist

organizations, however, are a different animal altogether and must be considered separately.

Additionally, any strategy designed to deter nuclear EMP must maintain the freedom of the United States to respond across domains. Should an adversary employ nuclear EMP with the intention of solely targeting U.S. space assets (though the physics of a high-altitude nuclear detonation would likely result in effects terrestrially as well), the United States should be clear in its declaratory policy that it maintains the freedom and capability to respond to the perpetrator both in space and on earth. Due to the fact that rules of engagement in space are not established and norms of weapons in space are increasingly challenged, the risk of nuclear EMP employment specifically designed to effect space assets is rising. In creating a strong policy on responses to nuclear EMP in space, the United States may well lead the way in establishing deterrence norms about the weaponization of the space domain, which in turn complicates the risk calculus for actors looking to exploit vulnerabilities in space and enhances terrestrial deterrence strategies.

Though deterring nuclear EMP against the U.S. homeland is priority number one, the likelihood of nuclear EMP employment is far higher in theater because the utility in an "escalate to de-escalate" strategy is greater. Deterring an actor from employing a nuclear weapon at high-altitude above a conflict zone not only requires the credible capability of U.S. and allied forces to survive enough to respond quickly and in kind, but requires a declaratory policy that is detailed and clear in its approach to response. The United States must credibly convince the actor that crossing the nuclear threshold with the employment of EMP would not only prompt devastating U.S. action against the regime's homeland in the form of targeted nuclear response against military assets, such

as identified nuclear weapons facilities (ensuring the inability to launch additional nuclear weapons), but overwhelming conventional response as well.

Deterrence of the employment of nuclear EMP against the U.S. homeland looks slightly different because the intended effects are different, are intended to occur on a much larger scale and impact the U.S. civilian population in significant and potentially long-lasting ways. The ability of the United States to credibly deny an adversary the capabilities or chance to employ nuclear EMP against the United States is much more important in this scenario than it is in theater. U.S. nonproliferation and counter-proliferation efforts will go a long way in denying adversaries like Iran, North Korea and terrorist organizations the ability to acquire sophisticated enough technology to launch a nuclear EMP attack from their own territory. Denying their ability to launch an attack from a mobile position, such as a freight cargo ship in the oceans off the coast of the United States, is much more difficult and depends upon international cooperation in intelligence and interdiction efforts. Improved homeland missile defenses with the capability to monitor and destroy missile threats before they exit Earth's atmosphere and hardened, survivable space assets (both civilian and military) would also contribute to credible denial efforts for actors like Russia and China who would not be affected by efforts to control technology and materials.

The key in deterring nuclear EMP against the U.S. homeland is in convincing an actor that their attempt at crippling the United States will either not be as effective as intended or will not succeed at all. The greater the survivability of the United States, the greater the chance of instant and overwhelming response, therefore making the risk greater than the potential reward. If the United States can succeed in credibly defending

the capabilities needed to respond to a nuclear EMP attack, such as strategic nuclear weapon systems, communications, and command and control, then an aggressive declaratory policy in which nuclear employment is not a last resort is much more effective; this of course does not mean that an overwhelming conventional response would not be seen as proportional. However, the United States should make clear that self-deterrence will not be a consideration in response to nuclear EMP attacks against the U.S. homeland, eliminating any doubt that the United States would be unwilling to respond to a nuclear non-casualty event with nuclear weapons.

The act of deterring a terrorist organization from employing nuclear EMP is more difficult, though not impossible. Declaratory policy and threats against the "homeland" of a terrorist organization are less effective because terrorist organizations are often located amongst innocent civilian populations and within the borders of sovereign nations, who may or may not have been involved or complicit in an attack. In the case of terrorist employment of EMP, self-deterrence is a serious consideration on the part of the United States. That being said, terrorism and terrorist employment of WMD is not an abstract concept to U.S. national security experts and planners. If those same experts can be convinced of the reality of nuclear EMP as a threat to the U.S. homeland, that is likely a community that can galvanize efforts to protect critical infrastructure against the threat. As Freedman explains, "the argument that deterrence does not work with terrorism can be challenged, not because for every terrorist challenge a sure-fire form of deterrence can be devised, but because over time it becomes apparent that this is a threat for which the community has made adequate provision to the point where, even if some attacks succeed, little of political consequence will follow and those responsible can expect they

will be hunted down and punished"[114]. In this same vein, if the United States can convince state actors, like Iran, that their sponsorship or aid of a terrorist organization in acquiring nuclear EMP capabilities will be treated with the same severity of response as those who perpetrated the attack itself, the United States may be successful in deterring terrorist acquisition of EMP capabilities in the first place. However, proportional response means little to a terrorist organization who already has the capability and threats of U.S. nuclear employment against them are neither very credible nor realistic. Instead, strategies of containment and disruption are most likely to prevent a terrorist organization from acquiring the necessary capability and strategies of prevention and denial are most effective in convincing a terrorist organization that nuclear EMP will not succeed in achieving their goals. Though terrorist employment of WMD in less sophisticated ways, such as crude bombs in trucks or pressure cookers, would be devastating, it would be far less consequential for the United States in the long-term than an effective nuclear EMP attack.

Nuclear EMP poses a unique deterrence challenge for the United States, a country which has typically relied upon traditional strategic deterrence strategies to deter high-end nuclear employment and large-scale conventional conflict. Nuclear EMP in the 21st century, while still employment of a nuclear weapon, exists in an inherently different threat realm as an asymmetric tool. It is for this reason, and the potential crippling impact on U.S. capabilities, that nuclear EMP represents such an attractive option to U.S. adversaries. The United States must recognize this fact and shift its own thinking regarding the utility of nuclear EMP for a range of adversaries. In doing so, the United States will not only increase its own understanding of strategic deterrence in the 21st

century but also begin to effectively deter threats and defend the U.S. homeland, U.S. allies and friends from actions that threaten to alter the security landscape for years to come.

CONCLUSION

The United States has faced a myriad of threats since those first nuclear weapons tests in 1962 exhibited electromagnetic pulse effects, from all-out nuclear war to terrorism to regional conflict. It is highly unusual that a threat of an era long thought over would return to be more salient than it was at its inception. However, as the United States became increasingly reliant on technology and advances in communications, energy technology, transportation, electronics and military capabilities proliferated, a vulnerability – an invisible Achilles heel – presented itself. Adversaries of the United States did not walk away from the Cold War era in the same way the United States did and they learned different lessons from the capabilities and strategies of those decades. The United States developed strategies dependent upon its ability to assert its military dominance, enabled by capabilities like precision strike and advances in communications and electronics. These capabilities and the technology that enables them, are the Achilles heel adversaries seek to exploit.

While the United States attempted to reduce reliance on nuclear weapons, they became increasingly valuable to actors who could never compete with conventionally superior adversaries. The United States, in many ways, became intellectually lazy in its assessment of adversary motivations, capabilities and intentions. These trends have contributed to the complex security environment of today, one in which the United States finds itself existentially vulnerable to a threat it doesn't believe is there in any meaningful way. This is reflective of the kind of thinking that precipitated the attacks of September 11, 2001: a lack of creativity and out-of-the-box thinking that results in almost willful

blindness to credible, potentially devastating threats that, once they occur, change the fundamental fabric of the nation.

As discussed and analyzed in the pages here, the United States has the tools to prevent or deter this threat, if it is willing to acknowledge it. The following are recommendations for the United States government and its friends and allies to best deter and prevent the unthinkable from becoming reality:

1. Immediately invest in the protection of critical infrastructure, especially those that would take the longest to repair or replace (Large turbines, generators, high-voltage transformers, key regional electrical grid stations, air traffic control, water filtration and distribution centers, government communications, command and control, critical components of the financial industry, and perhaps most importantly, space assets – especially low-earth orbit satellites, both commercial and military). Some individual U.S. states have begun to invest in their own protections against EMP. Maine, Virginia and Arizona have all passed their own laws about hardening against EMP. Florida has established a Cyber and EMP Legislative working group[115]. The Federal Government can follow by expanding the National Cybersecurity and Critical Infrastructures Act of 2014 to include threats from nuclear EMP and implementing the recommendations of the EMP Commission reports as well as the 2006 Quadrennial Defense Review.

2. Publicly classify employment of a nuclear weapon to create EMP effects as an act that crosses the nuclear threshold, no exceptions.

3. Develop a sophisticated and specific deterrence strategy for EMP attacks against the U.S. homeland and EMP attacks in theater. Conduct studies to determine the utility and impact of ambiguity on deterrence of nuclear EMP[116].

4. Specifically identify nuclear EMP as a threat in publicly released policy and strategy documents, such as the National Security Strategy, Quadrennial Defense Reviews, National Planning Scenarios, etc. Send a signal to adversaries that this threat does not go unnoticed by the U.S. government. Lay the groundwork for contributing to deterrence and denial.

5. Improve U.S. cross-domain capabilities. Actively participate in exercises independently and with allies demonstrating cross-domain operational capabilities.

6. Strengthen partnerships with U.S. allies and friends to improve intelligence and interdiction of nuclear material and ballistic missile technology.

7. Seek to improve U.S. missile defense capabilities to recognize and deny nuclear EMP attacks.

8. Define the responsibilities of the Federal Government, state and local governments and the private sector in recovering from an EMP attack against the U.S. homeland. Equip and train individuals and agencies to respond specifically to EMP effects. As of 2008, the EMP Commission was unable to convince the Department of Homeland Security to include an EMP attack as one of the National Planning Scenarios[117]; this should be priority number one in terms of equipping federal agencies with responsibilities and action items in the event of a nuclear EMP attack.

9. Continue to fund, for the next five to ten years, the Congressional EMP Commission which was re-established in the 2016 National Defense Authorization Act. Require reports on the study requirements as laid out in the NDAA, including the vulnerability of U.S. military systems; the evolving current and future threat; new technologies, procedures and contingency planning efforts to protect against EMP; priorities for protection in each U.S. state; and the degree of vulnerabilities in cascading failures[118]. Expand the study requirements to include a study of the deterrence requirements and strategies that may be employed against the threat of nuclear EMP for each actor capable of executing the threat.

The United States remains the pre-eminent military power in the world and continues to lead the way in technological advancements. As the security environment becomes more complex, U.S. leadership will continue to play a role in creating a safer world for many across the globe. To ignore capabilities and intentions that threaten that role, not to mention the lives of its citizens and military personnel, is to ignore the fundamental responsibilities and values the United States has for so long upheld. The threat of nuclear EMP is real, present and clear. It is long past time the United States take action to mitigate this threat and modernize its approach to deterrence in the 21st century.

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[2] Huessey, Peter. "Electronic Doomsday for the U.S.?" January 13, 2016. https://www.gatestoneinstitute.org/7214/electro-magnetic-pulse-emp.
[3] Kirkpatrick, Melanie. "Why We Don't Want a Nuclear-Free World." *The Wall Street Journal*, July 13, 2009.
[4] Detwiler, Peter. "Failure to Protect U.S. Against Electromagnetic Pulse Threat Could Make 9/11 Look Trivial Someday." *Forbes*, July 31, 2014. http://www.forbes.com/sites/peterdetwiler/2014/07/31/protecting-the-u-s-against-the-electromagnetic-pulse-threat-a-continued-failure-of-leadership-could-make-911-look-trivial-someday/#179321387fcd
[5] Wilson, Clay. “HEMP and HPM Devices: Threat Assessment.” *CRS Report for Congress,* July 21, 2008.
[6] As is discussed in more detail further in the paper, the 2016 NDAA included a provision which required the formulation of a new commission on the EMP threat. At the time this paper was written and completed, the commission had not yet come to conclusions or published any results of their findings. This paper can – and likely will – be updated upon completion of that commission for any changes to the level of threat as examined.
[7] Many thanks to my colleague, Rear Admiral Sam Paparo, for his insights, contributions and editing of this section.
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[9] *Global Strategic Trends out to 2040*. Report. Strategic Trends Programme, Ministry of Defence. 2013, xxiii.
[10] Ibid, 95.
[11] *Global Trends 2030*, xi.
[12] Ibid, iii.
[13] *Global Strategic Trends 2040*, 94.
[14] Mugg, James. “Russian Military Modernization: Everything Old is New Again”, *Real Clear Defense*, January 17, 2017, http://www.realcleardefense.com/articles/2017/01/17/russian_military_modernisation_everything_old_is_new_again_110645.html.
[15] *Global Trends 2030.*
[16] *Global Trends 2030,* iv.
[17] Ibid, 5.
[18] Ibid, iii.
[19] *Global Strategic Trends 2040,* 135.
[20] *Global Trends 2030*, 59.
[21] Ibid.
[22] Ibid, 67.
[23] Ibid.
[24] Foster, Jr., John S. et al. *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack*, Electromagnetic Pulse Commission, 2004, 47.
[25] It is important to note that rogue states such as Iran and North Korea were parties to the NPT though North Korea left the treaty in 2003 and Iran, though it remains a party, has been found in noncompliance of its treaty obligations.
[26] "Obama Prague Speech on Nuclear Weapons: Full Text." *Huffington Post*, May 6, 2009. http://www.huffingtonpost.com/2009/04/05/obama-prague-speech-on-nu_n_183219.html
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[29] Kristensen, Hans M. *Russian Nuclear Weapons Modernization: Status, Trends and Implications.* Issue Brief. Federation of American Scientists. September 29, 2014.

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[31] In this instance, "first-use" is used instead of employment, because it is the name of the policy, widely used throughout the nuclear weapons community. The term first-use will appear in discussions of the U.S. policy as well, as the Obama administration debated adopting a no-first-use policy for U.S. nuclear weapons.
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[33] Pry, Peter Vincent. *Apocalypse Unknown: The Struggle to Protect America from an Electromagnetic Pulse Catastrophe*. Washington, DC: Task Force on National and Homeland Security, 2013.
[34] "China", *Nuclear Threat Initiative*, April 2015. www.nit.org/learn/countries/china/nuclear/.
[35] Ibid.
[36] Schneider, 2007.
[37] "Iran", *Nuclear Threat Initiative,* October 2015, www.nit.org/learn/countries/iran/missile/.
[38] In 1958, a scientist named James Van Allen discovered radiation belts in the Earth's magnetosphere. He agreed to participate in a military study on how these radiation belts (later named Van Allen belts) were affected by disruptions caused by the detonation of a nuclear weapon. There is no evidence, however, that the United States was looking to determine how to use nuclear weapon effects as weapons themselves but rather to understand the effects on U.S. space assets.
[39] Quote by Peter Pry. "Joint Hearing before the Subcommittee on National Security and the Subcommittee on Oversight and Government Reform, House of Representatives, 114th Congress, First Session, May 13, 2015.
[40] The nuclear weapon dropped on Hiroshima was, in comparison, about 13 kilotons.
[41] Quote by Dr. William Graham. "Failure to Protect U.S. Against Electromagnetic Pulse Threat Could Make 9/11 Look Trivial Someday", *Forbes*, 31 July 2014. http://www.forbes.com/sites/peterdetwiler/2014/07/31/protecting-the-u-s-against-the-electromagnetic-pulse-threat-a-continued-failure-of-leadership-could-make-911-look-trivial-someday/#179321387fcd.
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[46] Wilson, 7.
[47] *"*America's Vulnerability", *Heritage.*
[48] Quote by Peter Pry. *Forbes,* July 2014.
[49] GWEN was dismantled and replaced with Single Channel Anti-Jam Man-Portable Terminal, or SCAMP, a high-frequency technology resistant to EMP that is lightweight, transportable and interoperable with today's DoD satellite networks. The satellites are unaffected by the detonation of a nuclear weapon and its associated radiation.
[50] Ibid.
[51] Schneider, 5.
[52] Ibid.
[53] Ibid.
[54] Wilson, *Congressional Research Service*, 17-18.
[55] Ibid.
[56] Ibid.
[57] Ibid.
[58] Ibid, 8.
[59] Elleman, Michael. "Iran's Ballistic Missile Program", *The Iran Primer*, U.S. Institute of Peace, August 2015.
[60] Quote by William Graham. *Forbes*, July 2014.
[61] Ibid.

[62] Schneider, NIPP.
[63] Pry, Peter. "Secure Freedom Radio Podcast with Frank Gaffney", *Center for Security Policy,* March 10, 2017.
[64] Joint Hearing before the Subcommittee on National Security and the Subcommittee on Oversight and Government Reform, House of Representatives, 114th Congress, First Session, May 13, 2015.
[65] Foster, EMP Commission, 2004.
[66] Foster, Jr., John S. et al. *Report of the Commission to Assess the Threat to the United States from Electromagnetic Pulse (EMP) Attack, Critical National Infrastructures*, Electromagnetic Pulse Commission, 2008.
[67] Ibid.
[68] Foster, EMP Commission, 2004, 21.
[69] Quote by William Graham, *Forbes*, 2014.
[70] "Improvising a Homeland Defense", *Staff Statement Number 17*, National Commission on Terror Attacks Upon the United States, 2004.
[71] Foster, EMP Commission, 2004, 26.
[72] Ibid, 26-28.
[73] Nye, James. "Why is the US Military Moving Back into 'Stargate' base deep under the Rocky Mountains a Decade After it was Abandoned?", *Daily Mail UK*, April 8, 2015, http://www.dailymail.co.uk/news/article-3031041/Why-military-moving-Stargate-base-deep-Rocky-Mountains-decade-abandoned.html.
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[75] Foster, EMP Commission, 2004, 31.
[76] Ibid, 36.
[77] Foster, EMP Commission, 2004, 124.
[78] Foster, EMP Commission, 2004, 39.
[79] Ibid, 40.
[80] Ibid.
[81] The requirement for EMP hardened systems exists as part of the acquisition process and as a result, many equipment components meet requirements individually but integrated systems do not and are not tested to certification (with the exception of strategic force components). The challenge of overall system protection is often seen as a disincentive to applying the necessary rigor throughout the acquisition process in terms of EMP protections. Cost concerns are often also cited as a reason why EMP requirements are not upheld throughout the acquisition process. Typically, the expense of hardening entire systems against EMP averages about 3-5% of the total cost of the system.
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[83] Ibid.
[84] Ibid, 44.
[85] Ibid, 48.
[86] Foster, EMP Commission, 2008, viii.
[87] Barron, James. "The Blackout of 2003: The Overview, Power Surge Blacks Out Northeast, Hitting Cities in 8 States and Canada; Midday Shutdowns Disrupt Millions", *The New York Times*, August 15, 2003.
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[96] Carafano, James and Weitz, Richard. "EMP Attacks – What the U.S. Must Do Now", *Heritage Foundation*, November 17, 2010. http://www.heritage.org/defense/report/emp-attacks-what-the-us-must-do-now#_ftnref24

[97] "America's Vulnerability", *Heritage*.
[98] Dr. Peter Pry, in an interview with Forbes magazine, recounted a meeting with Russian officials in 2004 in which the officials admitted that Russia had "developed this super EMP weapon, and during the post-Cold War brain drain, some of our scientists went to North Korea'…They thought within a few years, North Korea could develop a super EMP weapon. The South Korean military intelligence came up with same conclusion – that Russian scientists were in North Korea developing their weapons." (Forbes, July 2014). If this is true, North Korea's intentions to employ nuclear EMP against the United States may be much more mature than originally thought. However, it is still unlikely that deployment of a super EMP weapon would be among the first options for North Korea if regime survival were at risk.
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[102] "Gauging the Threat", *Stratfor.*
[103] Huessey, "Electronic Doomsday".
[104] Pry, Joint Hearing on National Security and Government Reform, May 2015.
[105] Ibid.
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