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Considerations for More Effective Risk Management for Electromagnetic Pulse Events

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Abstract

For over two decades, the Congressional EMP Commission has warned that nuclear and naturally occurring Electromagnetic Pulses are an existential threat to the United States. A single "Super-EMP" weapon detonated over the center of the United States or a solar storm like the 1859 Carrington event could destroy the electric grid causing long-term power outages across the nation.

According to the EMP Commission, within a year, nine of ten Americans would die, as most Americans no longer have the skills to operate in a world without electricity. EMP has been the subject of numerous Executive Orders directing federal departments and agencies to harden US infrastructure against EMPs. In a show of bipartisan interest in EMP, the executive orders on the subject have survived from administration to administration. Congress has codified many of the requirements in the executive orders.

Considering the dire warnings of the EMP Commission and interest from both the Executive and Legislative branches, it would be reasonable to assume efforts to protect our infrastructure would be well under way. However, in 2017 the EMP Commission determined that federal departments had taken no actions to implement their critical recommendations. In 2021 the Biden Administration passed a one trillion-dollar Infrastructure bill. The bill did not include any mention of EMP.

Groups concerned with the EMP threat have expanded their outreach. In the absence of federal action, they have lobbied for actions by the states. Texas and South Carolina have introduced legislation requiring the electric grid to be protected from EMP.

States and companies considering EMP protection must place the EMP risk in context to other threats. The federal government is seeking to cut federal spending and there are no indications that protecting infrastructure from EMP will be a priority. Without federal funding, states will need to bear the financial burden. Funding for EMP protection will come at the cost of reduced funding in other areas, increased taxes or utility rates.

Before initiating EMP hardening efforts, states must conduct independent risk assessments. They must understand why the federal government has not prioritized EMP efforts despite recent unprecedent investments in the nation's infrastructure.

Protecting against EMP is too broad a concept upon which to base risk mitigation decisions. EMP is a generic term that has many subsets with varying degrees of risk.

The EMPs of concern are ones generated by solar storms and nuclear attacks against the United States. Not only are the initiating events different. but so too is the way they threaten infrastructure. Some argue that a massive solar storm is not a matter of when, and not if, and since the storm is inevitable this justifies hardening infrastructure against EMP. Even if this justification was sufficient, it would only justify hardening against Geomagnetic Disturbances (GMD). Hardening against the GMD generated by the solar storm does nothing to protect the electric grid from the “Super-EMP” weapon which is claimed to have the capability to kill most Americans.

This paper explores the different types of EMP and how each exploits vulnerabilities in infrastructure. The paper uses scenarios to highlight how natural and nuclear EMPs differ and require different approaches to assessing and managing risk. Lastly, the paper explores how different nuclear attack scenarios require tailored mitigations.

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Introduction and Overview

During Congressional testimony on March 5, 2008, Congressman Barlett of Maryland asked Dr Graham, Chairman of the Congressional Electromagnetic Pulse (EMP) Commission, if a “really robust EMP laydown” could inflict mass casualties on the United States resulting in eighty to ninety percent of the population perishing in one year. Dr Graham responded “We think that is in the correct range. We don’t have experience with losing the infrastructure in a country with 300 million people, most of whom don’t live in a way that provides for their own food and other needs. We can go back to an era when people did live like that. That would be—10 percent would be 30 million people, and that is probably the range where we could survive as a basically rural economy.” (US Congress, 2008)

The 2017 EMP Commission’s Chairman’s Report begins with “The critical national infrastructure in the United States faces a present and continuing existential threat from combined-arms warfare, including cyber and manmade electromagnetic pulse (EMP) attack, as well as from natural EMP from a solar superstorm… scattered, incoherent, and inadequate responses are a clear indication that for at least the last decade, critical national infrastructure protection from EMP has been largely ignored or dismissed by major departments of the U.S. government.” (First EMP Commission, 2019).

In 2016 the Government Accountability Office (GAO) assessed Federal Agencies actions to prepare for an EMP attack against the United States. (Government Accountability Office (GAO), 2016) GAO found key federal agencies had taken various actions to address electromagnetic risks to the electric grid, and some actions align with the recommendations made in 2008 by the Commission to Assess the Threat to the United States from Electromagnetic Pulse Attack. (Future references will use the term “EMP Commission”)

In 2017 The EMP Commission assessed the federal Departments and Agencies responses to the GAO and determined that the Federal Government had taken no action on their critical recommendations. They were also highly critical of the US Intelligence Community regarding EMP, stating “The report by the Joint Atomic Energy Intelligence Committee (JAEIC) on EMP issued in 2014 is factually erroneous and analytically unsound… and a threat to national security….” (EMP Commission, 2017, p. 43)

On March 26, 2019, President Trump issued Executive Order 13865, *Coordinating National Resilience to Electromagnetic Pulses.* A key part of the executive order is paragraph 6(a)(ii) “Within 1 year … the Secretary of Homeland Security, in coordination with the heads of other agencies as appropriate, shall, using appropriate government and private-sector standards for EMPs, assess which identified critical infrastructure systems, networks, and assets are most vulnerable to the effects of EMPs.” DHS determined that all electrical systems not specifically hardened to EMP are vulnerable to the effects of E1, depending on the intensity of the pulse. Most of the requirements from the executive order were codified in law (6 UCS 195(f)) and the Biden administration chose not to rescind or update the executive order.

On February 27, 2019, Dr George Baker testified to the Senate Committee on Homeland Security and Government Affairs that “industry and government are largely ignoring the Congressional EMP Commission’s findings and recommendations.” (Senate Committee on Homeland Security and Governmental Affairs, 2019, p. 4)

On November 15, 2021, President Biden signed the 1 trillion-dollar Infrastructure Investment and Jobs Act (IIJA). The IIJA allocated over $30 billion to modernizing the nation’s energy infrastructure. The Biden administration highlighted programs to make the grid more resilient to “wildfires, extreme weather, and other natural disasters” but EMP is not mentioned. (The Biden White House, 2023)

In July 2023 the Department of Energy published *The High-Altitude Electromagnetic Pulse (HEMP) Application Guide*. The document highlights some of the challenges companies will face when assessing and mitigating risks from nuclear EMP. According to DOE, “It is not expected that industry and regulators will quickly become experts in performing HEMP assessments and implementing HEMP protections. Performing many of these activities is complicated and requires specific expertise and experience that is not commonly found.” (Energy, 2023, p. 7)

In 2023 the Department of Defense awarded the Defense Programs Award of Excellence to the team leader who led a team “that completed several studies that characterized the impacts of EMP on critical infrastructure.” An April 4, 2024, web posting from Los Alamos National Labs stated “Yes, we know a nuclear explosion will generate an electromagnetic pulse (EMP), which, depending on the circumstances, could disrupt certain electronic equipment, but the doom and gloom scenarios will not happen. That stuff belongs in Hollywood… Some unlucky people may end up with fried electronics, but most of us, at the worst, will just have to reboot our computer or cell phone.” (Los Alamos National Labs, 2024)

Problem Statement

With conflicting information from the federal government, congressional commissions and national laboratories, what steps, if any, should companies and states take to address the threat from EMP?

Discussion

To mitigate the threat of EMP we must first understand why the EMP Commission considers EMP “an existential threat” to the nation. A careful reading of the EMP commission’s 2017 Chairman’s report provides insight. “The United States—and modern electric power- and electronic-based civilization more generally—face present and continuing existential threats from naturally occurring and manmade EMP and Combined-Arms Cyber Warfare on our military and on our critical national infrastructures.” (EMP Commission, 2017, p. 4)

The report highlights that adversarial nations have identified the electric grid as vital to the functioning of the United States. Recognizing this, adversaries are developing a wide range of options to attack the grid, including Combined-Arms Cyber Warfare conducted by nations like Russia, China, North Korea and Iran. The EMP Commission assessed that these countries “may use combinations of cyber, sabotage, and ultimately nuclear EMP-attacks to impair the United States quickly and decisively by blacking-out large portions of its electric grid and other critical infrastructures.”

In addition to the man-made threats to the electric grid, we must also consider extreme solar storms that create Geomagnetic Disturbances (GMD) which can generate Geomagnetically Induced Currents (GIC) exceeding the grids protection standards.

The existential threat is the destruction of the electric grid. EMP is one of the attack vectors that adversaries may use to destroy the grid.

Before proceeding with more detailed discussions on HEMP and Solar Storms we must recognize that many areas of critical infrastructure have a degree of resilience to short-term power disruptions

Even mundane events such as overgrown trees touching power lines can disrupt power. The largest blackout in North American history was caused by overgrown trees touching a powerline. The August 14, 2003 event cut power to an estimated 50-million people. While most had their power restored within days, some isolated areas were without power for weeks. The Department of Energy's final report placed economic impacts between "$4 billion and $10 billion."

The impacts from power outages go beyond economics. The National Institute of Health conducted a long-term study of the 2003 outage. In 2013 they reported the outage contributed to "90 excess" deaths. (National Institute of Health, 2013, p. 3). Even short-term power outages can be fatal.

While power outages can have severe consequences, they are relatively common. The Department of Energy estimates power outages cost the U.S. economy approximately $150 billion each year. (The Biden White House, 2023).

Because short-term power outages are common, by necessity, many critical functions have been designed to mitigate short-term power disruptions. Regulators have imposed requirements in many sectors to include energy, health care, water and wastewater and communications. Governments at all levels consider short-term power outages when managing risk.

The private sector and government agencies have some degree of resilience from short-term power outages, as long as there are no interceding events such as an E1 pulse that damages critical electrical components necessary to implement mitigations.

Solar storms/GMD:

Solar storms can create very intense GMDs across large portions of the earth which can then create GICs. These GMDs primarily impact systems with long conductive lines like those found in the electric grid. While extensive damage to components in the electric grid is possible, damage to equipment in other sectors is unlikely.

The most recent GMD causing significant power disruptions was on March 13, 1989. This GMD caused widespread disturbances to the bulk power systems in North America and left 6-7 million customers without power.

According to the North American Electric Reliability Corporation (NERC) report on the March 13th incident "the loss of all static compensators on the La Grande network caused system disturbance, damaged some strategic equipment and rendered other major pieces of equipment unavailable." Most customers had power restored in 9 hours, but some customers were without power for longer periods due to damage to the distribution system. (The North American Electric Reliability Corporation (NERC), 1989, p. 41)

The power industry has improved its ability to deal with GMDs. Between May 10 and 12, 2024, the earth experienced the strongest GMD in over two decades. Analysis by NERC found that "despite the intense GMD the Bulk Power Systems remained stable throughout the event." There were no significant blackouts attributed to the storm. (North American Electric Reliability Corporation, 2024, p. 2)

NERC Reliability Standard TPL-007-4 – *Transmission System Planned Performance for Geomagnetic Disturbance Events* provides guidance for managing GMDs. (North American Electric Reliability Corporation, 2019) Some experts believe the guidance underestimates the frequency of potential catastrophic storms and urge higher thresholds for protection of the electric grid thereby reducing the likelihood of long term power outages.

The debates regarding the intensity of future storms and the preparedness of energy companies to prevent long term outages will continue. Evidence suggests that over the past 15,000 -years at least nine extreme solar storms, known as Miyake events, have occurred. The Miyake events are assessed to be more powerful than the 1859 Carrington event, which is the most powerful solar storm in recent history. (Kirby, 2023) Fortunately, these events are rare.

Forecasting space weather events is still in its infancy. While the Space Weather Prediction Center can provide early warnings of solar storms, they are unable to accurately predict whether the storm will be structured to cause damage to the electric grid.

For now, there is insufficient information for other critical infrastructure sectors to significantly modify their existing power outage mitigation strategies based on the threat from GMDs.

The burden to protect from GMD is on the electricity subsector. All other sectors must plan for short-term power outages.

Nuclear High Altitude EMP (HEMP)

Nuclear High Altitude EMP (HEMP) is unique. HEMP can damage infrastructure in all sectors. A nuclear detonation above 20 km can generate multiple EMP pulses depending on the Height of Burst (HOB). Dr George Baker provides a description of those fields and their interaction with critical infrastructure.

“The first, a “fast-pulse” EMP field, also referred to as E1, is created by gamma ray interaction with stratospheric air molecules. The resulting electric field peaks at tens of kilovolts per meter in a few nanoseconds and lasts a few hundred nanoseconds. E1’s broadband power spectrum (frequency content from DC to 1 GHz) enables it to couple to electrical and electronic systems in general, regardless of the length of their cables and antenna lines. Induced currents range into the thousands of amperes and exposed systems may be upset or permanently damaged.

The second “slow-pulse” phenomenon, is referred to as magnetohydrodynamic (MHD) EMP, or E3, and is caused by the distortion of Earth’s magnetic field lines due to the expanding nuclear fireball and the rising of heated, ionized layers of the ionosphere. The change of the magnetic field at the Earth’s surface induces a field in the tens of volts per kilometer, which, in turn, induces low-frequency currents of hundreds to thousands of amperes in long conducting lines only (a few kilometers or longer) that damage components of long-line systems, including the electric power grid and long-haul communication and data networks.”

The E1 pulse threatens equipment in every sector while the E3 pulses are largely a threat to the electric grid. What is often misunderstood is that no single nuclear detonation generates maximum E1 and E3 pulses. Variables such as weapons yield and altitude change the intensity of each of these pulses. Some examples are below.

- Optimal height for E1 generation is approximately 75 km while optimal height to generate E3A is approximately 400 km and E3B is approximately 140 km.
- A detonation at 75 km does not create E3 but creates strong E1.
- A detonation near 140 km will maximize the E3 pulse while the E1 pulse will be weaker than a detonation at 75 km but the pulse will cover a larger area.
- A detonation at 400km would significantly reduce the intensity of both the E1 and the E3B at ground level when compared to the fields generated if the weapon is detonated at altitudes indicated above.

Since the same weapon can generate a variety of effects, weapons must be specifically targeted to achieve effects. In the case of E1, an adversary would need to choose between a much weaker field over the entire US or an intense field over a region of the country.

Reputable organizations have differing views regarding basic information needed to assess the risk from HEMP. The EMP Commission claims an E1 pulse of 200 kilovolts per meter (kV/m) is possible due to the existence of a "super-EMP" weapon. The state of Texas is considering a 100 kV/m standard for the electric grid. The Department of Energy in its January 11, 2012, memo provided E1 waveform guidelines. DOE set testing recommendations at 25 kV/m for current threats and 50 kV/m for future "possible consideration."

HEMP is extremely complex, and assessing the risk is not straight forward. The risk from a HEMP event will largely be dependent on the number of weapons, the specific weapons used and the effectiveness of their targeting.

The sections below provide an analysis of the E1 and E3 threats. The intent is not to define which standard is correct but rather to highlight the need for well-defined scenarios when considering the risk from HEMP. Scenarios enable decision makers to understand the likelihood of an event, tailor mitigations and determine residual risk. Additionally, scenarios facilitate "red teaming" to determine if mitigations can easily be defeated.

As we will see in the Russian scenario presented by the EMP commission, the commission indicates that even the Department of Defense's most strategic system's EMP mitigations could be defeated by proper EMP targeting. This fact must be considered when assessing the risk to critical infrastructure and proposed standards.

There is no question a nuclear weapon detonated above the United States will generate an EMP that damages some critical infrastructure. The difficult question facing policy makers is "How much EMP risk is acceptable?" To answer this, they cannot simply default to the worst case EMP scenario. Following this logic, they would also need to consider the worst-case nuclear scenario.

Policy makers must consider the threat in context. Every dollar spent against EMP is a dollar not available to address other threats that include weather, aging infrastructure, cyber-attacks by foreign nations and terrorism.

To determine the HEMP risk, policy makers should seek answers to the following questions.

- Why has the federal government failed to act on the critical recommendations from the EMP Commission?
- Which threat is greater E1 or E3 and why?

- Can specific areas of the grid be targeted for protection based on the expected attack?
- What are the up front and recurring costs for protection, especially E1?

Not all nuclear attacks that create HEMP are equally threatening. The height of burst, design of the weapon, the weapons yield and other factors will determine the intensities of the various EMP pulses. A basic understanding of the different pulses and their impact on infrastructure is essential for states to make informed decisions.

As Texas assesses the risk from HEMP and considers HEMP protection for the electric grid, they must require those advocating for HEMP protection to include specifics regarding the weapons and their employment. Without this information, policy makers cannot effectively gage the likelihood of an attack or the associated risks. Below are issues that should be addressed by the legislature.

E1

Texas is considering hardening the grid to 100 kV/m against E1. This requirement is four times the current recommendation from the Department of Energy and two times the amount recommended by DOE to future proof the grid against potential threats. It appears the basis for the 100 kV/m standard is the existence of "super-EMP" weapons reported by the EMP commission.

HEMP E1 is sensitive to altitude. The EMP Commission acknowledges this as their Russian HEMP attack scenario included fourteen "super-EMP" weapons with EMP bursts are at "30-100 kilometers HOB to maximize peak field strength". (Pry, 2017, p. 53) The 200 kV/m referred to by the EMP Commission is the maximum pulse if the "super-EMP" weapon is detonated at the optimal height between 30-100km as noted in the Russian scenario.

Figure 1 below from Metatech (Metatech, 2010, p. 2.13) demonstrates how altitude affects the E1 pulse. (Note: The original Metatech graph did not include attack scenarios. The scenarios are included to facilitate discussions) We will use this chart to analyze and compare the two attack scenarios proposed by the EMP Commission.

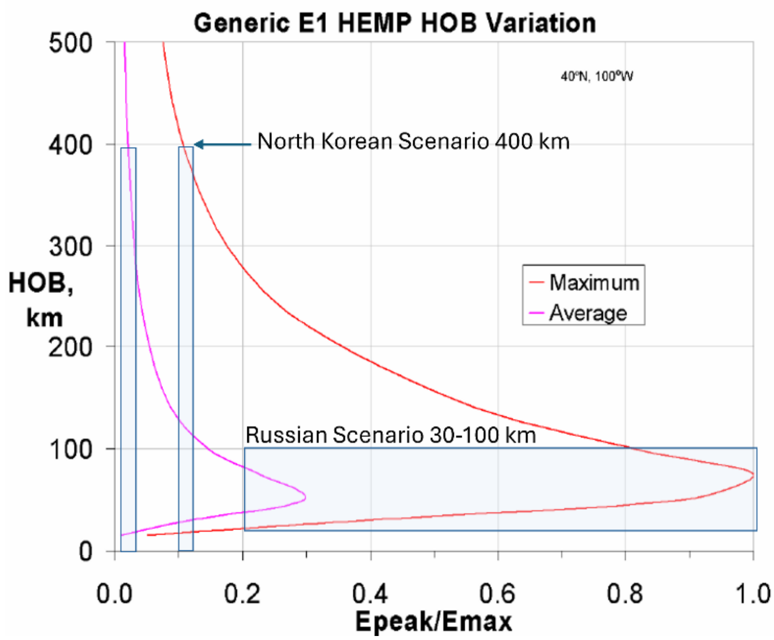


Figure 1

Chart assumes the use of a "Super-EMP" weapon.

Korean Attack Scenario

The Korean attack scenario proposed by the EMP Commission involves a single "super-EMP" weapon at 400 km above the geographic center of the US. Based on the Metatech analysis, the height would limit the strength of the E1 pulse. At 400 km the maximum E1 pulse on the ground would be 10-12 percent of the peak or 20-24 kV/m at locations to the south of the detonations. The average pulse would be less than 5% or below 10 kV/m.

If the Department of Energy is correct, and the maximum pulse is 25 kV/m, a detonation at 400 km would generate an E1 pulse with maximum intensity around 3-4 kV/m and an average exposure near 1 kV/m.

The strength of the E3 pulse within the US would be a fraction of the pulse if the detonation occurred at lower altitudes. Severe damage from the E3 pulse in this scenario is unlikely.

Russian Attack Scenario

The Russian scenario highlights why scenarios are important when assessing risk mitigations. In this scenario, fourteen “super-EMP” nuclear weapons are detonated at heights to generate 200 kV/m. According to documents on the EMP Commission website, the 200 kV/m E1 pulse would be strong enough to defeat the most robust HEMP protection used by the military for its nuclear command and control systems. (Pry, 2017, p. 16)

To place this threat in context, a single Russian Borie-Class submarine can carry 16 Bulava submarine-launched ballistic missiles (SLBMs), each with up to six warheads. (Johns, 2024) With a single submarine, Russia could target 96 sites. If Texas were to adopt the 100kV/m standard, would it be effective considering just a few weapons detonated at optimal height over Texas would defeat the 100 kV/m standard?

Even if the electric grid were to survive because it was protected to 100 kV/m, all other sectors would have extensive damage as they have no similar level of protection. Therefore, if Texas accepts the existence of the “super-EMP” weapon and implements the 100 kV/m on the electric grid, there must also be consideration for imposing the same standard on communications and other critical systems.

If the Department of Energy’s testing recommendations of 50 kV/m are more indicative of adversarial capabilities, the 100 kV/m standard being considered by Texas may represent a significant over investment in EMP protection.

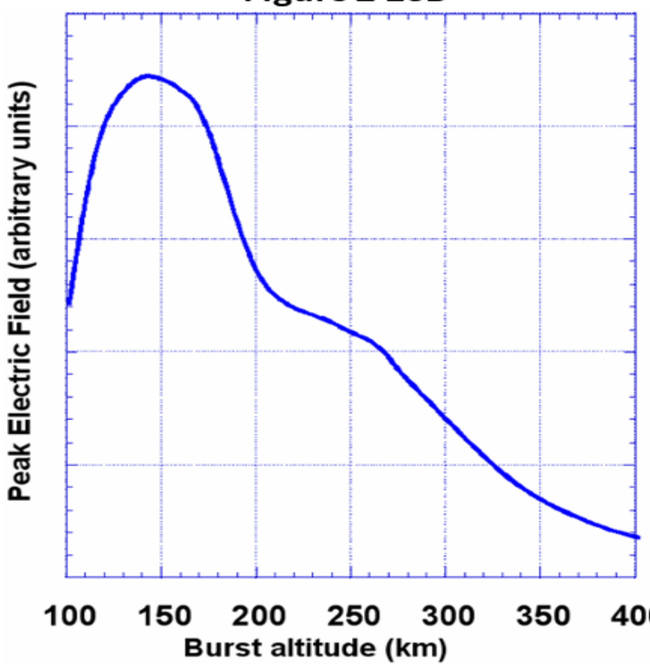
E3

As with E1, there are varying perspectives regarding the level of protection needed for E3. The Department of Energy memo of January 11, 2021, placed the E3 wave form at 50 v/Km while Texas is considering 85 v/Km.

By requiring both E1 and E3 standards at the proposed levels Texas is preparing for an attack from two separate nuclear weapons. A single nuclear weapon detonation is unlikely to generate the 100 kV/m E1 pulse and the 85 v/Km E3 pulse.

Before implementing these standards, the Texas legislature should fully understand the scenarios needed to generate these pulses. The EMP Commission provided attack scenarios for an E1 attack but did not provide similarly detailed scenarios for an E3 attack. By understanding the weapons required and the potential threat actors, Texas legislators can make informed decisions regarding the threat from E3.

Figure 2 E3B



Optimal heights for strong E3B pulses require weapons detonated at approximately 300km and 140 km (Figure 2) respectively. Generating E3A requires the detonation to be near the equator (Metatech, 2010, p. 2.5) while E3B creates the strongest pulses near the location of the detonation. (Metatech, 2010, p. 2.28) E3A becomes more intense with higher yield weapons. E3B saturates with yields around 100 kilotons. However, higher yield weapons would increase the area exposed to E3B pulses.

At 140km the detonation will also generate an E1 pulse that has the potential to impact infrastructure within a circle with a radius of 1294 km (804 miles). The E1 strength will be approximately 60 percent of the maximum possible E1 pulse if the weapon was detonated at its optimal height for E1 (see Figure 1). Assuming this was a “super-EMP” weapon the maximum pulses would exceed the 100 kV/m. It is unclear if “super-EMP” weapons specifically designed to create E1 will have strong E3 pulses.

Due to the altitude required for strong E3, above 100 km, delivery of the weapon is limited to ballistic missiles. While the EMP Commission postulates delivery by jets and high-altitude balloons, the altitude required to generate strong E3 pulses exceed the world record altitude for aircraft and high-altitude balloons. These delivery methods can reach heights to generate E1 pulses. However, they can only reach the extremely low end needed for E1 which would minimize both the intensity of the E1 pulse and impacted area.

E3 is primarily a threat to transformers in the electric grid. Based on open-source material the strongest E3 fields are in a relatively small area. Figure 3 from the EMP Commission shows the areas, in red and yellow, which would be at greatest risk. (EMP Commission, 2004).

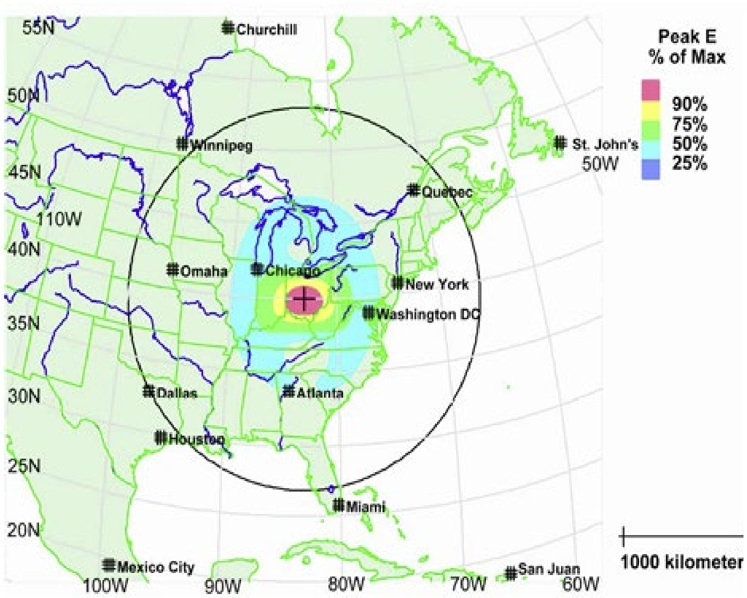


Figure 3. Illustrative EMP Effects – Slow Pulse Protection and Recovery of Civilian Infrastructures

While there are parts of the country with a high density of transformers, multiple weapons would be needed to destroy transformers that are geographically dispersed. Additionally, not all transformers in areas of potentially high E3 pulses may be impacted. The amount of current that enters the electric grid from an E3 pulse is highly dependent on the conductivity of the geological formations upon which they sit. For example, areas within Texas have geological formations which may not be conducive to creating strong GIC in the electric grid. Understanding how geology impacts the generation of strong GICs in the electric grid is the subject of much study. The White House operates the Space Weather Operations Research and Mitigation (SWORM). The SWORM is an interagency group with one subgroup focusing on Space Weather's impacts on infrastructure.

The SWORM obtained funding for nationwide magnetotelluric (MT) surveys to identify which parts of the country are most susceptible to GIC. These surveys were completed in 2024 and can inform to what extent areas may be susceptible to GMD.

When assessing risk from E3, Texas must consider that multiple weapons are required to generate strong E3 pulses in geographically dispersed areas. Areas not specifically targeted would likely experience power disruptions from the cascading effects. For this reason, risk assessments must address direct attacks against Texas infrastructure and mitigating the cascading effects should other areas of the country be attacked.

Other Considerations

EMP Commission concerns that US Nuclear Deterrence is Ineffective

There is little disagreement that an attack on the United States using a nuclear weapon would be catastrophic. The United States maintains its nuclear capability primarily to deter such attacks. The 2022 Nuclear Posture Review states "As long as nuclear weapons exist, the fundamental role of U.S. nuclear weapons is to deter nuclear attack on the United States, our allies, and partners." (Department of Defense, 2022, p. 1)

The EMP Commission raised concerns that existing deterrence programs may not be effective against countries like North Korea. Another concern is that, because EMPs do not directly cause fatalities, some countries might opt to use them, believing this would reduce the likelihood of the US conducting a nuclear counter strike.

These issues have been addressed. While we have no way of attributing the change in the US deterrence policy to the findings of the EMP commission, there are indications that the US has taken note of the changing security environment. The 2022 Nuclear Deterrence Strategy states:

"The United States continues to rely on nuclear weapons to deter all forms of strategic attack – including nuclear employment of any scale – and high consequence attacks of a strategic nature using non-nuclear means…. Given that the U.S. global alliance network is a military center of gravity, the United States will continue to field flexible nuclear capabilities and maintain country-specific approaches that reflect our best understanding of adversary decision-making and perceptions."

The US is also taking a more nuanced approach to nuclear deterrence. *The 2022 Nuclear Posture Review* contains a shift in nuclear deterrence. Recognizing different countries requires different strategies, the 2022 strategy contains requirements for country-specific strategies and plans. "Central to U.S. deterrence strategy is the credibility of our nuclear forces to hold at risk what adversary leadership values most. Effectively deterring – and restoring deterrence if necessary – requires tailored strategies for potential adversaries that reflect our best understanding of their decision-making and perceptions." (Department of Defense, 2022, p. 11)

Terrorism:

The EMP Commission raised concerns that a terrorist organization may conduct an EMP attack on the US.

For the US to be targeted by a terrorist nuclear weapon specifically to damage the infrastructure by EMP, the terrorist must acquire a nuclear weapon and the ballistic missile capability to deliver the warhead. While other delivery methods such as high-altitude balloons and jets may be feasible, they could only reach altitudes which would generate a weak E1 pulse and no E3 pulse. The lower altitudes would also limit the area exposed to the weaker E1 field.

Legislators must recognize that there are differing views on how terrorist would act should they acquire a nuclear weapon and a delivery system. Some experts believe that terrorist would choose to attack a city and kill as many Americans as possible. The EMP Commission presents reasons why terrorists would choose to deploy the weapon as an EMP. The Individuals and organizations espousing the likelihood of either scenario believe terrorist have good justification for choosing one over the other. Legislators should consider the differing viewpoints.

Global Impacts:

The detonation of a nuclear weapon will not only damage infrastructure in the United States. A high-altitude nuclear detonation will likely result in the loss of all low earth orbit (LEO) satellites due to trapped radiation. Maj. Gen. Michael Traut, head of German Space Command, stated at the 2024 Munich Security Conference that "if somebody dares to explode a nuclear weapon in high atmosphere or even space, this would be more or less the end of the usability of that global commons."

The global, indiscriminate impact of a high-altitude nuclear detonation may serve as further deterrence for the use of nuclear weapons. However, if a HEMP attack is considered a viable threat warranting mitigation, the potential loss of space assets must be addressed as well. The loss of low earth orbit satellites is a near certainty while the EMP effects on terrestrial infrastructure has a significant degree of uncertainty.

For additional information on risk related to the loss of space-based capabilities see my previous paper at Sam Houston State University, *Risk to Critical Infrastructure Due to Dependence on Access to Space-based Capabilities.* https://shsu-ir.tdl.org/server/api/core/bitstreams/07d48fe0-46f4-4ac1-9dc3-254cb7cba90e/content

Conclusions:

Nuclear and naturally occurring EMPs are sufficiently different and must be treated separately in risk management. The risk assessment process is complex, and input must be considered from a variety of experts. Failing to properly define the risk will likely result in ineffective mitigation planning and improper allocation of limited resources.

States should coordinate with the federal government when conducting EMP risk assessments as the federal government has access to subject matter experts and classified information that can inform state actions.

Companies generally lack the resources to accurately assess the risk related to a nuclear attack on the United States. Lacking federally or state mandated requirements companies should not base power outage requirements on the threat from EMP. Companies should continue to plan for short-term power outages in accordance with existing guidance and best practices for their industry.

GMD

NERC standards address risk to the electric grid from GMD. Should research and development efforts identify areas for improvement, there are existing processes to modify the NERC standard. Any changes to the NERC standards should be based on the threat from GMD and not for HEMP E3.

While rare events like the previously mentioned Miyake events are possible, there is insufficient information for other critical infrastructures to significantly change their existing power outage mitigation strategies based on the threat from solar storms.

Companies outside of the electric subsector can coordinate with state regulating authorities to further understand the localized risks from GMD and whether utilities are complying with NERC regulations.

HEMP

HEMP is highly complex. The Department of Energy states that expertise in this area is not readily available. Determining who has nuclear weapons, when they might use them and how they would develop their target list is classified and highly complex. Each element comes with a degree of uncertainty. Uncertainty compounds as each of the elements are considered.

Likewise, experts in EMP have vastly different views on HEMP. The EMP Commission views it as an existential threat, but Los Alamos National Labs disagrees. Los Alamos views the doomsday scenarios as fiction.

Congressional testimony reveals that the federal government has largely ignored the findings from the EMP commission. (Senate Committee on Homeland Security and Governmental Affairs, 2019, p. 4) There are no federal requirements for HEMP hardening of the electric grid. The Department of Energy has indicated that they will not recommend the development of HEMP standards until they conduct testing against their waveform benchmarks and DHS has completed their EMP risk assessment. This leaves the private sector and states in limbo unless they decide to act unilaterally.

Private sector companies lack the ability to make well-informed decisions on which experts are correct. Should they trust Los Alamos or the EMP Commission? First, the private sector lack access to classified information regarding nuclear weapons. Secondly, as highlighted by the Department of Energy, expertise in this area is difficult to obtain. Left with conflicting views from reputable organizations such as the EMP commission and Los Alamos National Labs, and no expertise to independently assess the findings, companies have no basis to decide which organization is correct regarding risk from HEMP.

If the HEMP event results in short-term power outages, many private sector companies will have some degree of resilience based on their existing power outage mitigation plans. The longer the power outage, the less resilient companies will become. Preparing for long duration outages is difficult and expensive. Few companies are willing to commit resources to prepare for a long-term power outage based solely on the threat of a nuclear attack, especially when there are conflicting views on the HEMP risk.

States can impose HEMP requirements on utilities that operate within their jurisdiction and several states have introduced legislation to do so. States can overcome some of the challenges faced by the private sector. They have means to access classified information, and they can solicit input from expert witnesses. This places the states in a unique position to assess and manage HEMP risk.

Texas and South Carolina are considering requirements to harden the grid against HEMP. The Way Forward section contains recommendations for states as they consider how to manage risk from nuclear EMP attack.

Way Forward

Hardening the electric grid against EMP is a significant investment. Funds allocated for EMP protection will not be available to address other issues such as cybersecurity. Before legislating specific hardening, the state legislature should consider the following:

- Treat nuclear and manmade EMPs as separate threats. Protecting against one does not necessarily protect against the other.
- Coordinate with the federal government to understand why they have not implemented the EMP Commission's recommendations. The federal government invests hundreds of billions of dollars in nuclear deterrence and has a vast intelligence network. Disagreements with the federal government's information regarding adversarial capability and intent must be scrutinized to assess its validity.
- Seek access to EMP assessments from the Department of Defense, the Department of Homeland Security, the Department of Energy and Los Alamos National Labs. Specifically, seek the Joint Atomic Energy Intelligence Committee (JAEIC) report on EMP, the Department of Homeland Security EMP Risk Assessment and reports from Los Alamos on impacts to infrastructure. To expedite access to classified reports, states should use intelligence assets that are part of the state's National Guard. These individuals already have the required security clearances.
- Require claims of nuclear capabilities include the source of the information and, if known, whether it is consistent with US government assessments.
- Require those advocating for HEMP hardening to provide justifications with specific details. The justification should be in the form of scenarios that describe the number of weapons, proposed site of detonation, weapons yield and the countries of concern. Scenarios must specify which EMP pulses (E1 or E3) are of concern and the extent of damage from each pulse. Will the equipment be damaged or temporarily disrupted? Will the damage be regional or nationwide?
- States should use strategic planners and intelligence assets from the National Guard or other neutral parties to assess the proposed attack scenarios. These evaluations should focus on the viability of the proposed scenario and not on the vulnerability of systems to HEMP.

- States should not consider HEMP mitigations as all or nothing. Different attack scenarios generate different types of EMP pulses and could inform tailored mitigation strategies. For example:
    - If E1 is deemed a greater threat, due to the existence of a "super-EMP" weapon, should all lifeline sectors be hardened against E1 and the state accept risk from E3?
    - If E3 is considered a greater threat, should E1 hardening be limited to ensure the E1 pulse does not damage systems designed to protect the grid from E3?
    - If the scale of the proposed attack includes multiple weapons generating strong E1 and strong E3 pulses, should we consider surface detonation as well?
- States should include other effects from a high-altitude nuclear detonation such as the loss of space-based capabilities caused by the destruction of low earth orbit satellites resulting from a high-altitude nuclear explosion.
- States should coordinate with the Space Weather Operations Research and Mitigation (SWORM) group organized within the Executive Office of the President, the Department of Energy and the US Geological Survey to develop standards for GMD specific to the States electric infrastructure and geology.
- States should fund magnetotelluric surveys in key parts of the state to identify which areas of the state are most susceptible to Geomagnetically Induced Currents (GIC) caused by GMD or HEMP events. These can inform targeted standards similar to how the NERC standard for GMD considers latitude.
- Provide opportunities for opposing points of view to be presented and considered.

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About the Author

Jim Platt is the founder and president of Strategic Risk Integration. He spent two decades leading risk management programs for the Army and the Cybersecurity and Infrastructure Security Agency. From 2019 through 2024 Jim performed numerous duties in the National Risk Management Center. He led the Department of Homeland Security's efforts related to EMP and chaired the interagency working group that produced the 2022 Quadrennial National Electromagnetic Pulse Risk Assessment.

In collaboration with the Department of Energy, Jim led an assessment of nuclear power plant's capabilities to prevent catastrophic failures resulting from a nuclear EMP event.

From 2020 to 2024 Jim led an interagency group organized under the White House's National Science and Technology Council to assess and mitigate risk to critical infrastructure from extreme space weather, including naturally occurring EMPs. These efforts led to an updated Implementation Plan for mitigating space weather, shifting national efforts from a vulnerability-based to a risk-based approach.

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