Strategy Research Project

ELECTROMAGNETIC PULSE – A CATASTROPHIC THREAT TO THE HOMELAND

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USAWC CLASS OF 2011

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REPORT DOCUMENTATION PAGE						*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYY Y)* 24-03-2011	**2. REPORT TYPE** Strategy Research Project	**3. DATES COVERED** *(From - To)*
4. TITLE AND SUBTITLE Electromagnetic Pulse – A Catastrophic Threat to the Homeland		**5a. CONTRACT NUMBER** **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR(S) Colonel Robert S. Oreskovic		**5d. PROJECT NUMBER** **5e. TASK NUMBER** **5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Professor Kenneth D. Chrosniak Center for Strategic Leadership		**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army War College 122 Forbes Avenue Carlisle, PA 17013		**10. SPONSOR/MONITOR'S ACRONYM(S)** **11. SPONSOR/MONITOR'S REPORT NUMBER(S)**

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution A: Unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

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15. SUBJECT TERMS

Nuclear, Solar Geomagnetic Storm, Electrical Power Grid, EMP

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT UNCLASSIFED	**b. ABSTRACT** UNCLASSIFED	**c. THIS PAGE** UNCLASSIFED	UNLIMITED	26	**19b. TELEPHONE NUMBER** *(include area code)*

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

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This SRP is submitted in partial fulfillment of the requirements of the Master of Strategic Studies Degree. The U.S. Army War College is accredited by the Commission on Higher Education of the Middle States Association of Colleges and Schools, 3624 Market Street, Philadelphia, PA 19104, (215) 662-5606. The Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

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ABSTRACT

AUTHOR: Colonel Robert Oreskovic

TITLE: Electromagnetic Pulse – A Catastrophic Threat to the Homeland

FORMAT: Strategy Research Project

DATE: 24 March 2011 WORD COUNT: 5,549 PAGES: 26

KEY TERMS: Nuclear, Solar Geomagnetic Storm, Electrical Power Grid, EMP

CLASSIFICATION: Unclassified

The detonation of a single nuclear weapon at a high altitude above the United States, or a major solar geomagnetic storm, would create electromagnetic pulses which have the potential to catastrophically impact the survivability of the United States. The electrical power grid is fragile, and is extremely vulnerable to an electromagnetic pulse. Its failure would result in the loss of almost all logistical functions necessary to support our modern society. This paper will examine the causes, threats, probable effects, and what measures can be taken to mitigate the potential impact to the Homeland.

ELECTROMAGNETIC PULSE – A CATASTROPHIC THREAT TO THE HOMELAND

In his opening statement to the Senate Judiciary Committee Subcommittee on Terrorism and Homeland Security on August 4, 2010, Senator Jon Kyl, Republican – Arizona, made the following statement: "One threat to which the government is particularly ill-equipped to respond is the threat posed by an electromagnetic pulse or EMP attack. When a nuclear weapon is detonated hundreds of miles above the earth, the resulting radiation would interact with the Earth's atmosphere to produce an electromagnetic pulse. The resulting EMP waves would cause severe damage to electronic devices and just a single weapon could affect much of the United States. People aboard planes and those on life support systems at hospitals would be the first casualties. However, without power for medical care, food refrigeration and water purification and delivery, the death toll could climb to staggering proportions."[1]

Dr. Peter Pry is president of EMPACT America, a bipartisan non-profit organization concerned with protecting the United States from a nuclear or natural electromagnetic pulse (EMP) catastrophe. He was also a charter staff member of both the 2004 and 2008 Congressionally mandated commissions chartered to study the EMP threat. Dr. Pry stated "based on eight years of research and analysis, 50 years of data from nuclear tests and EMP simulators, and never-before-attempted EMP tests, the commission found that any nuclear weapon, even a low-yield one, could potentially pose a catastrophic EMP threat to the United States, mainly because of the great fragility of the electric grid."[2]

All modern societies are dependent upon electrical power to function. The long term loss of electric power would have cataclysmic consequences on the welfare and survival of the residents of the United States. Our modern society is not structured or resilient enough to meet the needs of its population without electricity. A full-up electrical grid is necessary to run the infrastructure of the country, from sustaining water supplies, food production, processing of waste, providing heat for warmth and cooking, providing cold for food storage, telecommunication, and for essential transportation and distribution of goods. The electric power grid is singularly the most vulnerable component of our infrastructure to an electromagnetic pulse type attack or event. Such a strike could destroy our electrical power grid for years, and it is estimated that within one year up to two-thirds of the population would die from starvation, disease, and societal breakdown.[3] The impact of EMP producing weapons or events cannot be overstated. Regardless of the debate on the level of the potential threat, the result of an attack or event would prove devastating to the Homeland.

What is an Electromagnetic Pulse?

In 2009 the North American Electric Reliability Corporation (NERC) and the United States Department of Energy (DOE) partnered in a study to address what they labeled "High-Impact, Low-Frequency risks to the North American bulk power system."[4] Their report identified and explained the risks posed to the power grid from an electromagnetic pulse. According to the report, an electromagnetic pulse could occur from two principal sources. First is a manmade high altitude detonation of a nuclear weapon over the United States. The second is caused by the sun in the form of a solar geomagnetic storm. In both cases, an electromagnetic pulse is generated which could be very destructive to the electrical power grid.

A high altitude electromagnetic pulse (HEMP), caused by the detonation of a nuclear weapon well above the earth's surface, produces not one single pulse, but essentially three different waveforms pulses referred to as E1, E2, and E3. The E1 pulse is an extremely fast and brief component of a nuclear EMP. It can quickly produce very high voltages in electrical conductors which will damage sensitive electrical equipment.[5] An E1 pulse is produced when gamma radiation from a nuclear blast knocks electrons from the atoms in the upper atmosphere. The electrons travel at near the speed of light, and produce a very brief, measured in billionths of seconds, electromagnetic pulse over a wide area. The higher the altitude of the detonation, the wider the affected area will be.[6]

A second type of pulse is labeled E2. This pulse appears a fraction of a second after the E1 pulse. The E2 has many similarities to the electromagnetic pulse produced by lightning and electronic systems normally have protection in place (for example surge protectors). But according to the EMP Commission, the potential threat of the E2 is that it immediately follows the E1. As a result devices which might normally have been protected from E2 type pulses are not because they have likely been damaged from the E1 pulse.[7]

The third form of pulse is the E3, which is very different from the previous pulses. The E3 component of the pulse is of a longer duration, and has the greatest impact on the electrical power grid because power transmission lines serve as receivers or antenna. The transmission lines absorb the E3 pulses and conduct the energy to vulnerable power transformers situated along the electrical grid. The E3 type pulse has properties similar to a geomagnetic storm which is associated with solar flares and the coronal mass ejections which the sun expels. In some cases solar storms and their E3 type waves could pose as big a threat to transformers and the electrical grid as high altitude nuclear detonations.[8] A principal reason the electrical grid is most vulnerable is the concept of “cascading failures.” That is if one node in the electrical grid fails the electrical load is transferred to another node, often causing an overload of the next node in line, and so on. In an EMP situation any undamaged elements of the power grid would probably be overwhelmed causing a widespread cascading shutdown.[9]

Historical Events

One of the difficulties with predicting or estimating the potential effects of an EMP event is that conducting actual tests, with nuclear weapons at high altitude for example, would obviously be extremely problematic. The same is true for geomagnetic storms. It is very difficult to recreate EMP on a large enough scale to draw reliable conclusions. But history has provided us with a few historical events to learn from.

In 1962 the United States detonated a nuclear weapon about 400 kilometers (250 miles) above Johnson Island in the Pacific Ocean. In Hawaii, about 850 miles away, electronic and electrical systems were affected. Street lighting failed, circuit breakers were tripped, and telecommunication relay systems were damaged.[10] On the surface, the impact or damage appeared minor, but there were a few factors to consider. First, the 850 miles distance of Hawaii from the detonation is a significant distance. Second, the manner in which the electromagnetic pulse interacts with electrons has much to do with the Earth’s magnetic field at the location of the blast. The Earth’s magnetic field is much stronger in the Northern Hemisphere then it is in the middle latitudes such as the Hawaiian Islands. Thus, the electromagnetic pulse from a nuclear warhead most likely would be much stronger and have a much greater impact in the Northern Hemisphere, such as in the United States.[11] And the third factor to consider is that the types of electronic circuit board systems used today are much more sensitive and vulnerable to EMP than the solid state, vacuum tube systems used 50 years ago.

Additionally, in 1962 the Soviet Union conducted a series of high altitude nuclear tests, exploding 300 kiloton nuclear weapons at approximately 60, 150, and 300 kilometers above their test site in South Central Asia. Information is limited and most was never made public, but damage was observed to both above ground and below ground cables, fuses, and a power supply components. In fact, the EMP from the 300 kilometer test started a fire in a city power plant some 600 kilometers away.[12]

Historical examples of the effects of an electromagnetic pulse are not limited to manmade nuclear explosions. Pulses are also created when the sun has a solar flare, which results in a coronal mass ejection. According to a 2008 report from the National Research Council of the National Academies "The effects of space weather on modern technological systems are well documented in both the technical literature and popular accounts. Often cited is the collapse within 90 seconds of northeastern Canada's Hydro-Quebec power grid during the great geomagnetic storm of March 1989, which left millions of people without electricity for up to 9 hours. This event exemplifies the dramatic impact that extreme space weather can have on the technology upon which modern society in all of its manifold and interconnected activities and functions critically depends."[13]

The largest solar storm ever documented took place in September 1859. It was crudely recorded by an astronomer named Richard Carrington. On Earth the northern auroras (Northern Lights), which are normally only seen from the Arctic Circle and above, were observed as far south as the Florida Keys and in Cuba.[14] Around the world telegraph operators received electrical shocks, telegraph paper caught on fire, and operators had to disconnect their equipment because of electrical arcs.[15] A geomagnetic storm at the level of the 1859 Carrington storm has never been experienced in modern society. Such a storm illustrates the potential threat the sun poses to the electrical grid, and ultimately the Homeland.

<u>The Threat from Manmade Sources (Other Countries and Non-State Actors)</u>

Any country with nuclear weapons and a delivery system could use a high altitude EMP strike to cripple the United States. The Arms Control Association, a national nonpartisan organization dedicated to promoting public understanding of and support for effective arms control policies, lists eight countries as currently possessing nuclear weapons. They are the United States, Russia, China, Great Britain, France, India, Pakistan, and Israel.[16] In addition, North Korea has worked steadily toward developing nuclear weapons and has conducted two known open source tests. The first was on October 9, 2006 and a second on May 25, 2009, both with inconclusive results.[17] A tenth country, Iran, is widely believed to be developing a nuclear weapon capability.

In an interview on February 13, 2011, former Secretary of Defense Donald Rumsfeld expressed his concern about the threat from an electromagnetic pulse attack from countries such as Iran and North Korea. His specific comments were “so that cyberwarfare, and electromagnetic pulses and the things that can avoid competition with large armies and large navies and large air forces clearly have leverage, an advantage. And because of that, they're attractive."[18]

What former Secretary Rumsfeld was referring to was Asymmetric Warfare. The type of tactic used in warfare when the weaker side employs unconventional means to offset the strength of the stronger side. It is widely recognized that no country or terrorist group could compete successfully with the United States in a conventional war; therefore, they would seek a method to gain advantage, or look to exploit a weakness. An electromagnetic pulse attack offers this asymmetric option.

If used, the employment of an EMP type weapon is more likely to be used by a country with a limited number of nuclear weapons, or a rogue organization or terrorist group. A high altitude EMP strike allows an aggressor to inflict long term damage to a wide area with as little as a single warhead. According to Dr. Peter Pry, president of EMPACT America, "A single nuclear weapon detonated at an altitude of 400 kilometers over the United States would project an EMP field over the entire country, as well as parts of Canada and Mexico."[19] Smaller warhead yields and/or warheads detonated at lower altitudes would still be very destructive, but to a lesser degree. Other factors related to the effectiveness of a nuclear EMP weapon are the distance from the detonated weapon, and any geographical features such as hills or mountains which may block the electromagnetic pulse. And finally, the strength of the Earth's magnetic field remains a factor, primarily because the EMP effects would be greater in the Northern Hemisphere as previously mentioned.

Another possible threat scenario could be for rogue nation(s) and terrorist group(s) to fire Scud type missiles with nuclear warheads from freighters or container ships off each coast, and a third from the Gulf of Mexico in order to inflict enough EMP damage to cover the continental United States. Simple Scud type missiles are fairly common and easily accessible.

It is acknowledged that Iran and North Korea possess a large number of missiles and continue to improve and test on the basic design. North Korea also continues to develop longer range missiles. In addition to Scuds, North Korea has developed the Nodong missile with a range of about 1,300 kilometers, a Taepodong-1 missile with a range of about 2,900 kilometers, and the Taepodong-2 with range of between 4,000 and 10,000 kilometers.[20] All of North Korea's long range missiles currently have reliability and design problems, and all must be launched from a fixed site. However, all have the potential to carry large enough payloads high enough to be used in an EMP attack.

Iran's most developed ballistic missile is the Shahab-3 with a range of about 2,000 kilometers. In September 2009 Iran successfully test fired this missile.[21] In testimony before the House Armed Services Committee on July 10, 2008, Dr. William Graham, who was the Chairman of the 2008 Congressional EMP commission, made the following statement in reference to Iran: "Iran, the world's leading sponsor of international terrorism, has practiced launching a mobile ballistic missile from a vessel in the Caspian Sea. Iran has also tested high-altitude explosions of the Shahab-3, a test mode consistent with EMP attack, and described the tests as successful. Iranian military writings explicitly discuss a nuclear EMP attack that would gravely harm the United States."[22]

The Threat from the Sun

According to Dr. Richard Fisher, who is in charge of the National Aeronautics and Space Administration's (NASA) Heliophysics Division, "The sun is waking up from a deep slumber, and in the next few years we expect to see much higher levels of solar activity. At the same time, our technological society has developed an unprecedented sensitivity to solar storms."[23]

Geomagnetic storms due to solar emissions have always occurred, and they are somewhat cyclical. There are two factors converging which together pose a threat to the United States. The first is that the sun is entering into period of increased solar activity. When the sun becomes more active the threat of a major solar flare with an accompanying solar coronal mass ejection is increased. The second factor is the high level of societal reliance upon modern technology. The 1859 Carrington geomagnetic storm demonstrated the power of electromagnetic pulses. In 2008 the engineering consulting firm Metatech Corporation conducted a study on the impact of geomagnetic storms upon the United States electrical power grid. The study was requested by the Congressional EMP Commission and the Federal Emergency Management Agency (FEMA). The conclusions were that severe geomagnetic storms posed a risk of long term power outages to major portions of the North American power grid. The study's main author, Dr. John Kappenman, stated that "not only the potential for large-scale blackouts but, more troubling, . . . the potential for permanent damage that could lead to extraordinarily long restoration times."[24] The study also concluded that "while a severe storm is a low-frequency-of-occurrence event, it has the potential for long-duration catastrophic impacts to the power grid and its users."[25] The most significant problem is that the EMP could damage electrical grid transformers and "these multi-ton apparatus generally cannot be repaired in the field, and if damaged in this manner, they need to be replaced with new units, which have manufacture lead times of 12 months or more."[26]

Electrical Power

The detonation of one or more high altitude nuclear weapons over the United States, or an extremely powerful geomagnetic solar storm, would cause little physical damage to either citizens or structures on the ground. But in the case of a nuclear weapon EMP the blast would create an electromagnetic pulse which, at a minimum, would result in the overload and destruction of a significant number of electrical systems and high technology microcircuits known as Supervisory Control and Data Acquisition (SCADA) systems. SCADAs are automated monitoring and control systems which, in most cases, have replaced human supervisory control. Our reliance on SCADAs has increased our vulnerability to an EMP because, if they become disabled, no back up exists to replicate these essential functions.

The level of damage from an EMP is dependent upon a number of factors previously described, such as the height, strength, and distance from the blast. Also affecting the EMP impact is the amount of geographic shielding and the Earth's magnetic field where the blast occurred. Because of these variables and a limited amount of testing it would be difficult to accurately predict the effect of the E1, E2, and E3 pulses on individual systems, such as automobiles, personal computers, computer networks, cell phones, and radios. Therefore, for the purposes of discussing the consequences of an electromagnetic pulse, I will narrow the focus to the electrical power grid. By focusing on the electrical power grid I will simplify the discussion without minimizing the potential effects. Electrical power is the cornerstone and foundation of our modern society. It impacts virtually all other infrastructure and services. Without electrical power almost all the tools of our modern society will eventually become useless.

The electrical power grid is a complex and interconnected system responsible for supplying electricity throughout the United States. The sources of electrical power generation in the United States are coal (45%) followed by natural gas (23%), nuclear (20%), and hydroelectric (7%).[27] A very small percentage of power is generated from "green" technologies such as wind and solar. Electricity is moved from the various power plants via transmission lines. Transmission lines are mostly above ground, but some, especially in urban areas, are below ground. Connecting the transmission lines are substations, or nodal points, where several lines meet. Within the substations there are transformers, which change the power from one voltage to another and move the electricity along the distribution system to the end user. Also located with the transformers are protective devices such as circuit breakers, meters, and data transmitting and control systems. In most cases these protective systems successfully safeguard other parts of the power grid from isolated problems such as power surges and lightning strikes.

Transformers are the critical link in the electric power grid. They are large, expensive, and custom built. None of these large transformers are built in the United States and delivery times for newly built systems under normal conditions are from one to three years. About 2,000 are in place throughout the Homeland, and only about 100 new ones are produced worldwide each year.[28]

The primary reason the electrical power grid is vulnerable to both manmade and solar electromagnetic pulses is because of long-distance and aged above ground electrical transmission lines. These transmission lines serve essentially as antenna for the pulse, especially the E3 component. All transmission lines lead to and from electrical transformers. The transformers are the key nodes of electrical power and they are the most vulnerable. An EMP strike, whether manmade or from the sun, could overload and thus burn out transformers. The result would be that electricity would no longer be transmitted, even if the actual power source was not damaged.

In the event of an EMP event and the loss of electrical transmission most power generation plants would be shut down. But the potential risk of nuclear power deserves special mention. In March 2011 an earthquake off the coast of Japan and resulting tsunami exposed the unique vulnerability of nuclear power plants. In emergencies a nuclear power plant cannot be quickly turned off. It takes days to shut down the reactors, and during this time coolant or water must be continuously circulated to keep the core from overheating. Diesel generators, with an abundant supply of fuel, pump coolant when a reactor is being shut down and no other outside source of electricity is available. In Japan, it appeared that at least one nuclear power plant had their backup generators at ground level. When the tsunami came ashore the generators were damaged and the means to keep the reactor cores cool was severely limited. This is a possible scenario following an EMP event, because the backup generators will most likely be damaged by the EMP. Another area of concern is the cooling of spent fuel rods. Spent rods still produce heat after use and are stored in large holding tanks filled will water. Without power to keep the tanks full, the water will eventually evaporate and radiation may be released. Even with fully functional generators pumping coolant to these critical areas, the requirement to eventually refuel the generators exists.

Logistical Impact Resulting from the Loss of Electrical Power

The long term loss of the electrical power grid would impact all logistical aspects of our modern society. Short of total nuclear war, the loss of electricity represents the most catastrophic threat to the Homeland. Some of the most important logistical functions in which our modern society relies upon are transportation, water, sanitation, health care, and communications.

The ground transportation industry is the key logistical component of our society and economy. The level of the immediate impact of an EMP strike on cars and trucks is unknown because the scope of EMP testing on vehicles is limited. In a worst case scenario, every modern vehicle with a microprocessor would be disabled. But even if many vehicles still functioned following an EMP event eventually they would require refueling, and without electricity existing fuel could not be pumped from underground storage tanks into vehicles. Additionally, the loss of electricity would limit the ability to move previously refined gas either by pipeline or truck. Even if other options were developed for fuel distribution, the loss of electricity would result in refineries becoming non-operative and no new fuel being refined. The ground transportation system would be severely degraded and eventually grind to a halt.

The loss of commercial trucking in particular would be devastating. According to the American Trucking Association in 2006 there were three million large commercial trucks on the road in the United States, and those trucks accounted for 69% of all tonnage distributed.[29] In addition, more than 80% of United States communities depend solely on trucking for delivery of their goods and commodities.[30] For example, most grocery stores stock less than a week's supply of food, for some perishable commodities such as milk, much less. Even if new food could be processed without electricity, it would still be very difficult to distribute. Urban areas with dense populations would find themselves most vulnerable, and very quickly run out of food supplies.

Municipal sources need electricity to both purify and pump drinking water. The loss of electrical power would almost immediately be felt in any size urban areas which rely on pumping stations to move and distribute water. Those who may live in more rural areas, with gravity fed water tower systems, would have clean drinking water for some additional time. Even Americans with private wells would be impacted because electricity is needed to run the pumps which bring the water from underground. The lack of electricity would bring our modern water drinking supply system to a halt.

Without electricity, sanitation would quickly become a significant health issue. Through the power of gravity, or by pumps, water effectively moves waste materials from businesses and homes. Pumping stations then transfer the waste to treatment facilities where the waste is processed. Without electricity, human waste removal would cease to function due to loss of water pumping (pressure) capability, and the non-operative SCADA systems discussed earlier. Once again, those in more urban areas would experience the impact sooner.

Similar health issues would occur if trash was not removed. Uncollected and deteriorating waste products create environments for the rapid growth of microorganisms, insects, and rodents. In such an environment it is likely that varied debilitating diseases would soon follow.

The modern healthcare system needs electricity to function. Hospitals have backup generators with a varied 3 to 30-day supply of fuel. Once the fuel is exhausted our healthcare system would revert back a hundred years in techniques and procedures. Additionally, new supplies of modern drugs could not be ordered, nor even manufactured, transported, or distributed. Existing supplies at hospitals and clinics would eventually run out. As a result, the medical field would experience difficulties treating new injuries and would not be able to respond to the increased diseases resulting from lack of clean water, sanitation, and altered diets. The young and old, and those with preexisting medical conditions, would suffer the most.

Another specific area impacted by an EMP event would be that of information and communications. Imagine an environment without working telephones, cell phones, email, any commercial internet communication, or television. These systems are all vulnerable to EMP and rely on electricity to operate. Command and control at the local, State, and even Federal level would be seriously impaired. The loss of communication would make it very difficult to coordinate aid and assistance.

While it is unknown how American citizens would respond in an environment where the electrical grid was lost, possibly for years, it is prudent to plan for the worst case scenario. Population centers, food production and distribution, housing, and almost every other aspect of life are built for a modern society relying on modern technologies and a full-up electrical grid. Civil unrest and the eventual breakdown of societal norms are almost certain as resources become scarce and governmental control is severely degraded.

Measures to Reduce the Threat

By now it should be evident that an electromagnetic pulse event has the potential to catastrophically impact the Homeland and affect our viability as a nation. Therefore, every possible measure should be taken to prevent a manmade EMP attack from occurring.

An EMP attack requires a nuclear weapon and the means to launch the weapon into a high enough altitude for the pulse properties to have effect. Nuclear non-proliferation is our national policy and it remains a top priority. But additional focus should be placed on missile and missile technology proliferation. The goal should be to prevent the sale of missiles, their components, and their technology to any nation not a firm ally of the United States.

Measures to Mitigate the Impact

If our intelligence services and Homeland defense systems are unsuccessful in preventing the launch of a nuclear missile, or a major electromagnetic solar storm takes place, there are procedures which can be taken to lessen the impact of an EMP strike, and measures to prepare the Homeland to better withstand the impact.

The absolute highest priority must be to modernize and protect the electrical power grid. As previously discussed, the power grid is the most critical component of our modern society. But in reality it is not possible to protect all of the numerous electrical systems from the effects of an EMP attack, as there are enormous amounts of components with assorted designs, ages, and manufactures resulting in varied levels of vulnerabilities. Therefore, initial priority should be to the most critical components of the electrical grid, the transformers and generators. Transformers and generators could be hardened with a surge protector type system which would absorb the EMP pulse and temporarily shut them down if struck. Additional critical components, spare parts, and generators should be ordered now, and stockpiled, and safely sheltered at locations geographically dispersed throughout the United States. Sheltering should be done in such a way to block harmful electromagnetic pulses. This could be done by putting as much mass as possible between the pulse and stockpiled equipment. Sheltering underground or in tunnels would provide substantial protection. Another method of protection is to put equipment and components in what is known as a Faraday Cage. A Faraday Cage is a metal container built around the item to be protected. It serves as a shield and redirects EMP properties into the ground.

The objective of preparing safety mechanisms and stockpiles is to limit the extent and amount of time electricity is lost. The total cost of most protective measures is relatively small, especially when no cost can adequately be associated and compared to the potentially catastrophic result of the entire electrical grid system being shut down for a lengthy period of time.

Dr. John Kappenman, who was the primary author of a study requested by the Congressional EMP commission and the Federal Emergency Management Agency (FEMA), believes that it is very feasible to install a surge suppressor type system to the "several thousand major substations and other high value components on the transmission grid" and harden the most significant 5,000 power generating plants.[31] In July 2009 testimony before the House Committee on Homeland, Dr. Kappenman estimated the cost of the basic level of safeguards to the electric power grid to be between $250- 500 million to protect the transformers and another $100-250 million to protect the power plants.[32] According to Dr. Kappenman, once installed, the surge protector type system would be capable of preventing at least 60% of nuclear or solar E3 type pulses.[33] Dr. Kappenman's plan would not protect individual electronic systems from E1 or E2 pulses, but it would at least provide a basic level of protection to the electrical power grid at a modest cost. And, Dr. Kappenman believes that such protection would mean the difference between a major inconvenience and societal collapse

In June 2010 the House of Representatives passed HR 5026, the ''Grid Reliability and Infrastructure Defense Act.'' The bill did not make it through the Senate and did not become law by the time the 111th Congress adjourned. The bill would have directed the Secretary of Energy "to develop technical expertise in the protection of systems for the generation, transmission, and distribution of electric energy against geomagnetic storms or malicious acts using electronic communications or electromagnetic pulse that would pose a substantial risk of disruption to the operation of those electronic devices or communications networks, including hardware, software, and data, that are essential to the reliability of such systems."[34] The passage of HR 5026, or a similar type bill, would have eventually forced the modernization of the United States' electrical power grid. The result would be a resilient electrical grid much better positioned to withstand the effects of an EMP event.

The 112th Congress has taken a step forward with introduction of HR 668, the "Secure High-voltage Infrastructure for Electricity from Lethal Damage" or the "SHIELD"

Act.[35] The bill was introduced in the House of Representatives in February 2011 by Representative Trent Franks, Republican-Arizona. The bill amends the Federal Power Act to protect the most critical components of the bulk-power system and electric infrastructure against the threat posed by EMP.

In conjunction with modernizing and hardening the electrical grid system, measures should be taken to keep the nation's transportation systems viable. As a backup to electrical power major fuel distribution points should have backup generators to pump fuel. Local gas stations should be required to maintain hand pumps. Oil refineries should have the backup capability to produce at least a minimal amount of new fuel in the absence of electrical power. And civil authorities must be prepared to control and prioritize the distribution of fuel.

Nationwide personal preparedness would greatly increase the resiliency of the Homeland. The Federal Emergency Management Agency (FEMA), in concert with State and local governments, should educate individuals and families about the importance of maintaining a minimum of a 30-day or more supply of food, and other emergency necessities. Americans must understand that they are responsible for their own well being from not only an EMP type event, but for natural disasters such as hurricanes and earthquakes.

Following an EMP event, contingency planning should be made to default command and control to the local level. Organizations such as the Army National Guard, Army Reserve, police, and fire departments will become the primary administrators at the local level, and should be equipped, supplied, and trained accordingly. Increasing preparedness will be expensive and require additional manpower from the Department of Homeland Security and the Department of Defense, but it is well worth the cost and effort. The objective is to support the population until electrical infrastructure capabilities are reestablished.

Conclusion

The detonation of a single nuclear weapon at a high altitude above the United States, or a major solar geomagnetic storm, has the potential to catastrophically impact the United States. The resulting scenario posed by an EMP type event is beyond comprehension for the majority of our leaders, and almost all of our citizens to grasp, because it is something we have never experienced on anything but a very small scale. Regardless, the threat is real and our modern electricity based society is extremely vulnerable. Reasonable and practical steps taken now by governmental agencies, in concert with utility providers, could greatly mitigate the consequences of such a devastating event. What is needed is a National level appreciation of the threat, and a National level effort to implement synchronized measures to do what is necessary to protect the Homeland and increase its resiliency. The challenges are not technical, but bureaucratic and regulatory. The solutions are within our grasp. The potential effects of inaction are catastrophic, and that alone should be enough cause for action.

Endnotes

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